Ecology of the Trees of Bukit Timah Nature Reserve

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Abstract

An inventory was carried out in Bukit Timah Nature Reserve to study the specific composition of the trees. For the sampling a systematic layout was used. The sampling unit was a cluster, with 4 circular tenth acre sub-units, so that the area of each cluster is 0.4 acre. Enumeration was done for all trees down to 24 inches (c.61 cm) gbh but for each cluster, in one of the circular subunits enumeration was down to 12 inches (c.30.5 cm) gbh. The idea was to have smaller-girthed trees to indicate recruitment.

In all, the 20-cluster sample, covering some 8 acres (3.24 ha) yielded 889 trees, belonging to 44 known families with 212 species. Twenty individual trees in 13 clusters could not be identified at all.

The specific composition of the forest conforms to that of a Coastal Hill Forest according to Symington's classification of the forests of Peninsular Malaysia. The dipterocarps show family dominance with 125 individuals out of a total population of 889 trees while the family Euphorbiaceae show the highest number of genera (11) and the greatest number of species (22). The other families with species preponderance are the Anacardiaceae, Burseraceae, Lauraceae, Myrtaceae and Leguminosae.

A parameter, called the Distribution Index (DI), is used to indicate spatial distribution (lateral spread) of the species within the community. This is simply the number of clusters in which the species occurred, its number of individuals being ignored. It is reckoned that this parameter, tabulated side by side with the sample total of the species affords a quick visual appreciation of the ecological influence of the species. In the sample, 121 species have been found to have a DI of unity, 41 with 2, 13 with 3, etc. Only 5 species have a DI equal to or exceeding 10.

A stand curve, and a species/area curve are given. The stand curve, an inverted "J", shows the typical content of uneven-aged stands and indicates good representation of trees in different girth classes. The species/area curve does not show flattening out, indicating that the sample has not reached a size which would have included most of the species.

For trees with gbh. $\geqslant$ 24 inches the mean density of the forest is 86 stems/acre compared to 103.3 stems/acre for some stands in a similar forest type in Malaysia. The difference is found to be statistically significant at the 0.05 level. The *Mischungsquotients*, varying between 1.3 and 2.0, however, compare well with those of stands in Malaysia and indicate great complexity of species.

The hypothesis is put forward that despite the small size of the Reserve and its isolated nature the species which are peculiar to the Coastal Hill Forest type and wielding structural and numerical dominance as a whole, would survive over a long period of time because their progeny have an innate ability to grow up in the shade within the ambit of the parent trees. Because of this, at any one time they have individuals of all sizes in the forest ranging from saplings through pole-sized to mature trees. This is a guarantee to species survival. On the other hand, species with low density which are not widespread and whose saplings require canopy opening to grow up, may gradually die out, the reason being that the chance opening of the canopy in their vicinity may not coincide with their fruiting, and a tree may die before such an opening. The demise of a tree itself can cause an opening in the canopy but again it may occur at a time when its saplings are completely absent. All these factors may lead to a decline in the overall floristic composition of the forest.

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I. Introduction

The forest on Bukit Timah Hill was made a nature reserve just before the Second World War and is protected under the Nature Reserves Act. The area is about 75 ha. (185 ac.) and the summit of the hill at 163.5 m (536 ft.) is reputed to be the highest point in Singapore.

Geologically the area consists of granite and because this rock type is used extensively as a road metal and construction material several quarries have made extensive exploitation for the rock west and south of the Reserve. The topography ranges from gradual to steep and in some places the land falls to merge with steep-sided gulleys where granite outcrops and boulders abound. Outcrops can also be seen in many other places within the Reserve and along its boundary.

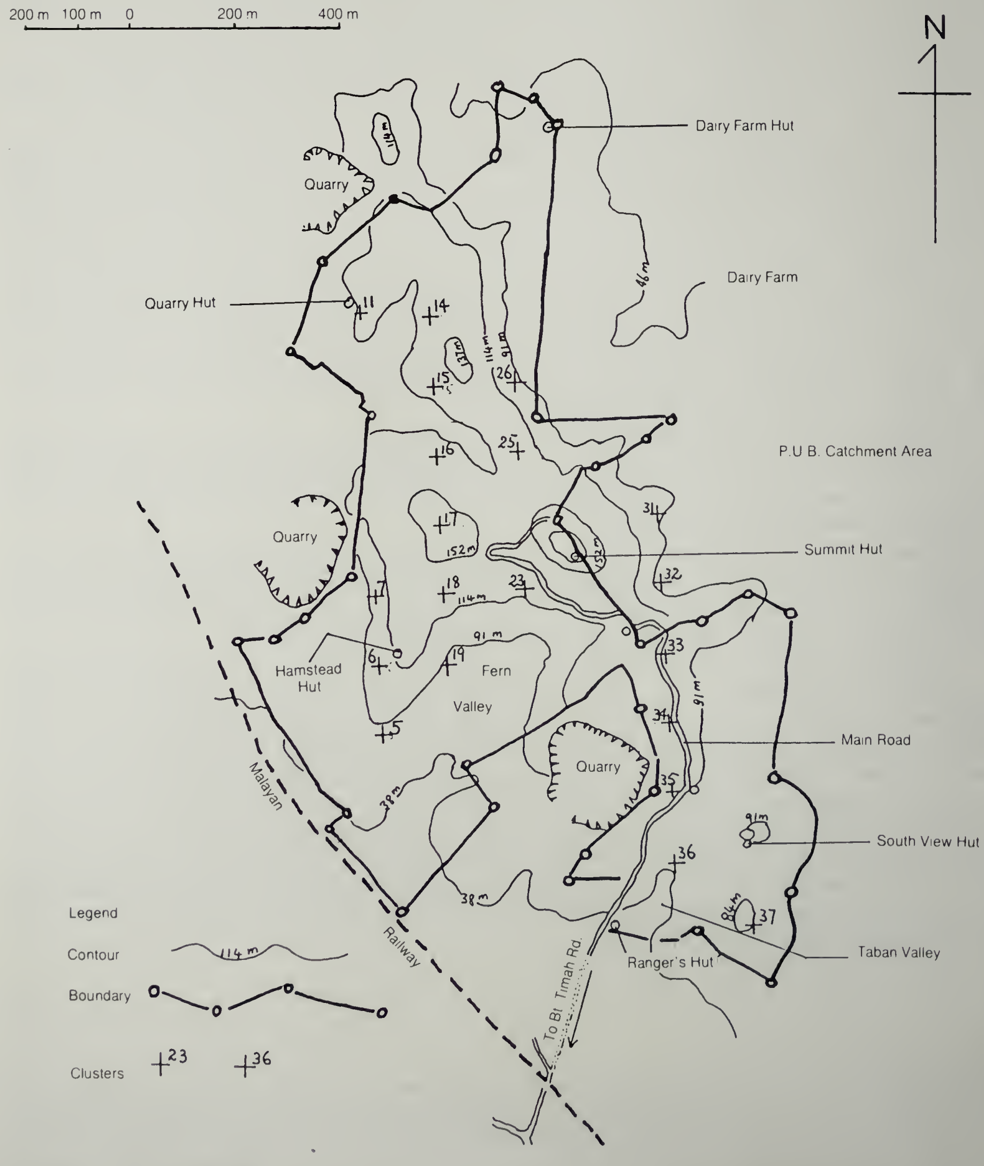

Fig. 1. Sketch Map of Bukit Timah Nature Reserve Showing Location of Sampling Units.

Until very recently to all intents and purposes Bukit Timah could be considered as part of the central catchment area in Singapore, being located on its western fringe and separated from it only by a pipe-line carrying water from Johore to Singapore. With the recent completion of the Pan Island Expressway, east of the Reserve, however, it is now completely isolated with non-forested areas on all sides. The Expressway is a six-laned major highway with ample road reserve.

The vegetation consists of stands of high forest and pockets of secondary forest along the reserve boundary at different stages of ecological succession ranging from open scrubland to pole-sized forest. The high forest appears undisturbed and is of a primary nature. In terms of specific composition the forest should best be classified as a Coastal Hill Forest (vide Symington (1942)). This is characterised by *Shorea curtisii* occurring at low elevation and its association with species which would otherwise occur only or predominantly in Hill Dipterocarp Forest, such as *Anisoptera curtisii* and *Artocarpus lanceifolius*.

At the time when Symington wrote his Manual of Dipterocarps it was thought that *Shorea curtisii* was probably endemic to the Malay Peninsula. However, more recent taxonomic works by both Meijer (1964) and Ashton (1982) have reported the presence of *Shorea curtisii* in the hills of Borneo and on islands off the Sumatran coasts. There is, however, no ecological work to elucidate its association with other species. It is, therefore, uncertain whether there exists a Coastal Hill type of forest in these places, similar to that under reference. If none exists then Bukit Timah is unique in that it is the southernmost habitat of a Coastal Hill Forest.

The Hill is botanically famous because it is the type locality of many species, the result of its being the collecting ground of many famous botanists, such as Ridley, Burkill, Holttum and Corner. In recent years teachers and students of both universities and secondary schools have made observations on the plant communities and animals in the Reserve (see for example, Whitmore & Wong (1959). Recently a guide book (1985) has been published in which common plants and animals are featured. As far as it was known before this survey was carried out no quantitative study had ever been made on the ecology of the trees. The survey was therefore initiated so as to create a scientific record of the tree species and their distribution in the Reserve. The work was carried out as an activity of the Singapore Branch of the Malayan Nature Society and the field work spanned a period of some three and a half years between June, 1974 and January, 1978. The actual area covered by the survey was only 3.24 ha (8.0 ac.). The apparently long period required to achieve this lies in the fact that field work was carried out as Sunday outings, once a month, and sometimes inclement weather rendered some Sundays impossible for work.

II. Method

(a) Design and Layout

The sampling units were located systematically. A systematic layout was preferred because although the Nature Reserve is relatively small there is great variation in topography and in the vegetation to be studied. As the study was not intended to be a statistical exercise but one which was aimed at revealing as much as possible the character of the forests, a random sample might not give the uniform spread of the sampling units over the Reserve. At the time of the survey a map of the Reserve with an Imperial* scale of 1 inch = 150 yds (approx. 1 cm = 54 m) was used as the base map for the sampling. A one-inch grid was laid over the map; the intersections

*The survey was initiated before the Metric System was adopted in Singapore. In order to facilitate direct comparison with results obtained in Malaysia and to avoid sometimes meaningless conversions, it was decided to present the results of the survey using the Imperial System.

of the grid were used as the centres of the sampling units. There were some 40 possible sampling units but only 20 could be completed during the period mentioned earlier. A map of the Reserve with the positions of the sampling units appears in Fig 1. It will be noted that two of the units, No.31 and No.32 were located outside the Reserve boundary but they were included in the survey as the forest appeared uniform and continuous with the forest within the Reserve boundary. (See, however, Section III(c) concerning No. 32.)

Each sampling unit is a cluster of 4 circular plots (sub-units) each with a radius of 37.25 ft. (c. 11.35 m) arranged along the cardinal directions (see Fig 2). The plot centre is 55 ft. from the cluster centre. A circular plot of 37.25 ft. radius has an area of one tenth acre, so that a cluster covers an area of 0.4 acre. Unless otherwise stated, the cluster forms the basis of the various analyses presented in this report.

(b) Location of the Clusters and Circular Plots

The job was made easy by the many paths and junctions present in the Reserve reference to which cluster positions could be located by the use of a compass and a 100-ft measuring tape. In order to correct for slopes the tape was pulled as horizontally as possible when measuring distances. If need be, such as on rather steep slopes, measurement was done step-wise for short distances instead of for a whole 100 feet.

Once the cluster centre was located, the tree nearest to the spot was marked and this was used as the working centre for the cluster. The centres of the 4 circular plots were located with reference to this tree. Likewise, trees were used to mark their centres. If they were of enumerable size they would be enumerated; otherwise they would be ignored during the enumeration.

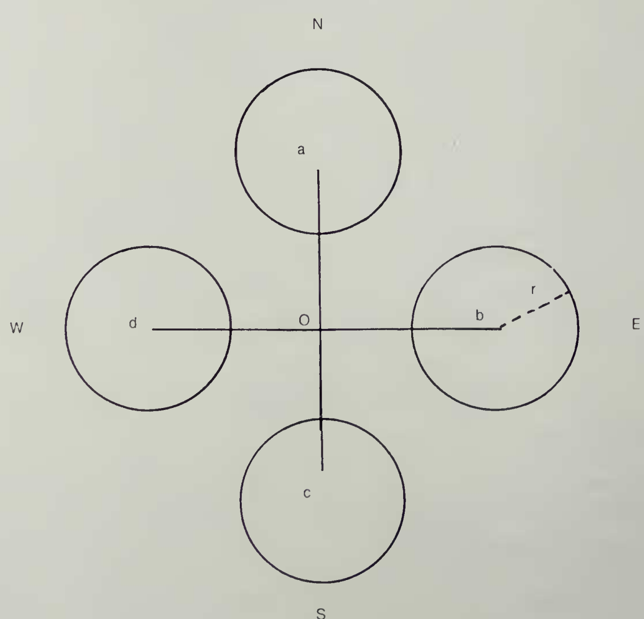

Fig. 2. Configuration and Size of the Sampling Cluster. O = Cluster Centre, Ob = 55 ft., r = radius of sub-plot = 37.25 ft., a,b,c,d, are respectively centres of sub-plots A,B,C,D. N,S,E,W are the cardinal points. Each sub-plot has an area of 0.1 acre. The area of the cluster is therefore 0.4 acre.

A quick inspection was made to ensure that none of the circular plots of the cluster would fall on man-made areas, such as a foot path or boundary. If any did, then the cluster centre was adjusted so that the plot(s) would avoid such an object as far as possible. Other than this, cluster location adhered strictly to what was indicated by the map.

Marking the sampling units with existing trees made our field work much easier than if we had to carry timbers or other similar materials to site for plot or cluster demarcation. Further, the circular plot was not demarcated. The boundary was the circumference, within seeing distance from the centre where the team leader, doing the booking, would be standing. When in doubt, a boundary tree was checked with the tape to see if it was in or out of the plot.

(c) The Enumeration

Within the circular plot all trees with a girth at breast height (gbh — 4 ft. 6 ins. or c. 1.37m from the ground) of 24 inches (c. 61 cm) or larger were measured for girth. But for each cluster, Plot A formed a special sub-sample in which girth measurement included all trees down to 12 inches (c. 30.5 cm). The idea was to use this to indicate recruitment and regeneration. For trees which had buttresses taller than 4 ft. 6 inches, measurement was done above the buttresses and if the buttresses were too tall to be reached, then an estimate for the girth above buttresses was made. In the case of species which have a tendency to produce coppiced shoots from ground level, the girth of each coppiced stem, meeting the requirement of minimum girth at breast height, was measured.

In the enumeration the book was closed after finishing each circular plot.

The choice of 24 inches as the minimum girth in the enumeration was somewhat arbitary. In order to get a good picture of the composition of the forest in relation to recruitment and regeneration, the lower the girth limit the more accurate the information. Indeed for regeneration study enumeration of the seedling population is essential. However, it is also a fact that for rain forest ecology, the smaller the tree the more difficult it is to identify and the present study shows that if we had lowered the enumeration girth for all plots to 12 inches instead of 24 inches, then we would have had to deal with a population nearly 70% larger than what we have got. In absolute terms we would have had to measure and identify an additional 600 odd trees. This would have been too cumbersome for Sunday outings!

(d) Species Identification

For this we relied mainly on sterile characters of the species. As we were working in a nature reserve, bark cut for identification purpose was kept to a minimum. Using such characters one had no difficulty identifying most of the larger trees, but for smaller trees, in many instances, we had to collect the fallen leaves and send them to the herbarium of the Botanic Gardens for further identification. In this study some 20 trees could not be identified at all. In the various lists presented in this report, the class called "Unknown" is the sum total of such difficult cases. (See Section III (b) for comments and plant names and their revisions.)

(e) Compilation and Analysis of Data

The bulk of the compilation and analyses was done using dBase III Plus, on an IBM PC, with a capacity of 640 KB and with two disk drives. dBase III Plus is a widely known and widely used software package but for our present study it has been found that the features mentioned below are examples of useful commands for our compilation and analyses. Using the "Index" mechanism followed by the "Total" command, one could generate a complete species list with sample total for

each species. Indexing in association with the "Set Unique" command also segregates species into mutually exclusive groups in different clusters. This facilitates species/area curve construction.

The programme is also extremely useful for the calculation of basal area by cluster with each figure being achieved by a single command! It also enables blocks of data, for example, lengthy tables, etc. to be transferred to a word-processor for further editing and reporting.

III. Results

(a) Some Stand Parameters

Table 1(a) presents some stand parameters of different clusters. Column 2 in the Table gives the actual number of stems encountered in the 0.4 acre cluster. Each figure is multiplied by 2.5 to convert it to number of stems per acre and the converted figures appear in Column 3. Column 4 gives the number of species present in each cluster. The *Mischungsquotient* (see Richards, 1964) of Column 5 is obtained by dividing Column 2 by Column 4 and it is simply the number of individuals per species within the stand. This is used as a measure of the degree of complexity of the stand. The larger this quotient is, the fewer the number of species in the particular stand.

Table 1(a). Some Stand Parameters — Bukit Timah Nature Reserve. (Based on trees with gbh >=24 inches).

Clust. Number (1)	Stem No. In The Cluster (2)	Stem No. Per Acre (3)	Species No. In Cluster (4)	Misc. Quotient (5)	Basal Area/Acre (6)
5	28	70	19	1.5	125
6	42	112	28	1.5	168
7	38	95	22	1.7	177
11	42	105	27	1.6	136
14	37	92	25	1.5	160
15	39	97	27	1.4	118
16	30	75	25	1.2	97
17	32	80	20	1.6	115
18	24	60	23	1.0	95
19	24	62	20	1.2	105
23	32	80	19	1.7	149
25	53	130	6	8.8	96
26	33	82	11	4.7	70
31	39	97	24	1.6	125
32	50	125	25	2.0	176
33	27	67	21	1.3	103
34	33	82	23	1.4	114
35	23	57	19	1.2	86
36	24	60	7	3.4	76
37	37	92	14	2.6	132
* Total	687	1720	405		2423
Mean	34.3	86	20.2		121.1

Column 6 gives the total basal area of each cluster. The basal area of a tree is simply its cross-sectional area at breast height and that for the stand is the sum of the basal area of all the trees within that stand. This is a density parameter.

Table 1(b). Densities of some Malaysian Stands of Coastal Hill Forest. (Trees with gbh>=24 ins.)

Location	Elevation (ft.a.s.l)	Plot size (acre)	Plot Total	Stems/ acre
Jarak Is.	50 — 200	0.5	40	80
	200 — 350	0.5	51	102
		1.0	91	91
Rumbia Is.	20 — 150	0.5	59	118
	150 — 300	0.5	53	106
Kg. Gajah	300 — 500	0.5	41	82
Perak	350 — 400	0.5	49	98
		1.0	90	90
Banang	350 — 500	0.5	50	100
Perak	700 — 850	0.5	40	80
	500 — 650	0.5	54	108
	250 — 350	0.5	64	128
Pangkor Is.	50 — 200	0.5	54	108
Soga, Johore	350 — 500	0.5	61	122
	900 — 1100	0.5	60	120
Gunong Raya Langkawi Is.	200 — 400	0.5	60	120
			Total	1653
			Mean	103.3

Source: Wyatt-Smith (1963), Table 12, Pg. III — 14/20, only figures for gbh>=24 ins have been extracted for conversion into densities presented here. All the non-island Forest Reserves, except Kg. Gajah, are within 3 to 6 miles from the sea. Kg. Gajah is within 15 miles from the sea.

Table 1(b) presents some figures on number of stems per acre derived from different forest reserves with Coastal Hill forest in Peninsular Malaysia, viz Jarak Island, Rumbia Island, Pangkor Island, Banang, Kampong Gajah, Soga and Gunong Raya on Langkawi Island. The relevant figures are extracted from Wyatt-Smith (1963).

The purpose is to compare this parameter with the figures presented in column 3 of Table 1(a).

The density figures of the Bukit Timah Forest show rather wide variation, with the values ranging from 57 to 130 stems per acre. The mean of the 20 clusters is 86 stems per acre. A t-Test, dealing with unpaired variates but with the variance of the two samples being equal, shows that this mean is significantly different from that of 103.3, the mean derived from the 16 stands of forests in Peninsular Malaysia, with the significance just missing the 1 per cent level. The Bukit Timah clusters have included 4 stands known to have disturbed or man made forest, viz. Clusters 25, 26, 36 and 37. Even if we exclude these from the t-Test, the conclusion is still the same.

Table 2. Stands of Disturbed or Man-made Forests. (All trees with gbh>=24 inches. See girth size equivalents in Section III(d)).

(a) Cluster 25 with *Adinandra dumosa* as the dominant species

Species	G1	G2	G3	G4	G5	G6	Total
1. Adinandra dumosa	0	0	30	6	2	0	38
2. Campnosperma auriculatum	0	0	1	0	0	0	1
3. Cratoxylon formosum	0	0	1	0	0	0	1
4. Gironniera parvifolia	0	0	0	1	0	0	1
5. Ixonanthes reticulata	0	0	1	1	2	1	5
6. Rhodamnia cinerea (R. trinervia)	0	0	4	1	0	0	5
7. Timonius wallichianus	0	0	2	0	0	0	2

(b) Cluster 26 also with *Adinandra dumosa* as the dominant species

Species	G1	G2	G3	G4	G5	G6	Total
1. Adinandra dumosa	0	0	18	3	0	0	21
2. Cratoxylon formosum	0	0	0	0	0	1	1
3. Eugenia linocieroidea	0	0	1	0	0	0	1
4. Ixonanthes reticulata	0	0	0	0	2	3	5
5. Ploiarium alternifolium	0	0	1	0	0	0	1
6. Rhodamnia cinerea (R. trinervia)	0	0	3	0	0	0	3
7. Streblus elongatus (Sloetia elongata)	0	0	0	0	1	0	1

(c) Cluster 36 with *Palaquium gutta* as the dominant species

Species	G1	G2	G3	G4	G5	G6	Total
1. Actinodaphne sesquipedalis	0	0	1	0	0	0	1
2. Artocarpus scortechinii	0	0	1	0	0	0	1
3. Litsea elliptica	0	0	1	0	0	0	1
4. Palaquium gutta	0	0	4	6	5	3	18
5. Pellacalyx saccardianus	0	0	0	0	1	0	1
6. Pimelodendron griffithianum	0	0	1	0	0	0	1
7. Shorea leprosula	0	0	0	0	1	0	1

(d) Cluster 37 also with *Palaquium gutta* as the dominant species

Species	G1	G2	G3	G4	G5	G6	Total
1. Adinandra dumosa	0	0	1	0	0	0	1
2. Antidesma coriaceum	0	0	0	1	0	0	1
3. Campnosperma auriculatum	0	0	0	1	0	1	2
4. Cratoxylon formosum	0	0	0	1	0	0	1
5. Dysoxylon sp.	0	0	1	0	0	0	1
6. Eugenia linocieroidea	0	0	4	0	0	0	4
7. Gymnacranthera forbesii	0	0	1	0	0	0	1
8. Gynotroches axillaris	0	0	0	1	0	0	1
9. Ixonanthes reticulata	0	0	1	1	0	1	3
10. Litsea elliptica	0	0	0	1	0	0	1
11. Gluta wallichii (Melanorrhoea woodsiana)	0	0	0	1	0	0	1
12. Palaquium gutta	0	0	7	7	1	3	18
13. Rhodamnia cinerea (R. trinervia)	0	0	1	0	0	0	1
14. Sindora sp.	0	0	0	0	0	0	1

It is, however, difficult to proffer an explanation as to why there should be a significant difference. One is tempted to surmise the forest at Bukit Timah is not that primary after all and that past creaming of the forest for small timbers by villagers living in the vicinities could have reduced the density.

Coming to the *Mischungsquotients* in Column 5 of Table 1(a), if we leave out the ones for clusters 25, 26, 36 and 37 for the time being, then we have them ranging from 1.0 to 2.0. If the quotient is 1 then it is the same as saying that within the particular stand every individual belongs to a different species! If it is 2 then we would expect to find two individuals to every species. From the figures we have it can be seen that the Bukit Timah high forest is very mixed and this is comparable to stands found in different parts of Peninsular Malaysia. Figures given by Wyatt-Smith (1963) for Pangkor F.R. Banang F.R., Bukit Lagong F.R. and Kampong Gajah F.R. also range from 1.3 to 1.9.

The quotients for Clusters 25, 26, 36 and 37 are certainly larger than that of the other clusters. As stated earlier large values indicate stands dominated by a few species. Reference to Table 2 will show that this is the case. Clusters 25 and 26 are dominated by a single species, *Adinandra dumosa.* These two stands are in disturbed forest lying at the fringe of the reserve and undergoing succession. Clusters 36 and 37 are dominated by *Palaquium gutta,* a species of commercial importance in the past because it yielded gutta percha, the raw material for chewing gum. Corner (1952) made passing reference to the trees planted in the Taban Valley and Clusters 36 and 37 were located therein.

In rain forest ecology one of the rather intriguing questions is how big a sample one must take in order to include most of the species in an area under investigation. One method employed to get some idea is the Species/Area Curve. Greig-Smith (1964) states that there are commonly three ways in which to construct such a curve, the most efficient being to take independent samples of different sizes within the study area and then plot number of species encountered against area of the respective sample. In this study of ours it was realised from the start that our sample size would never be able to exhaust all the tree species in Bukit Timah, bearing in mind that it has been variously estimated that in Peninsular Malaysia alone there are no less than 3,000 species of trees with 12 inches girth and larger. However, as a look-see exercise a plot is made here (Fig. 3) of species against area, the area of successive classes being cumulative upon the previous total, a method described by Greig-Smith (ibid) as being most inefficient.

Initial attempts to construct the curve included all 20 clusters and it produced a curve that seemed to rise in three steps. This was due to the fact that the four disturbed/man-made stands (see Table 2) mentioned previously, had few species and when the curve hit those stands, it flattened out, only to rise again when it hit again normal stands with more species. As it would not be logical to have a curve covering different known forest types, with obviously different specific composition, the four abnormal stands were taken out and another curve constructed. The resultant curve is shown in Fig. 3. It is noted that it is a relatively smooth curve with the initial portion (within the first 0.8 acre) rising steeply as expected; it then assumes a slightly more gradual slope but right till the end it is still on the rise, showing that our sample of 6.4 acres is far from having included most of the species.

(b) Specific Composition of the Forest

A complete list of species by families arranged in alphabetical order is given in Appendix 1(a). The "unknown" plants are those which we could not identify at all and these are distributed in 13 of the clusters.

Quantitative plant ecological work in the Region has been in progress in the past few decades, during which taxonomic revisions of the various families or genera,

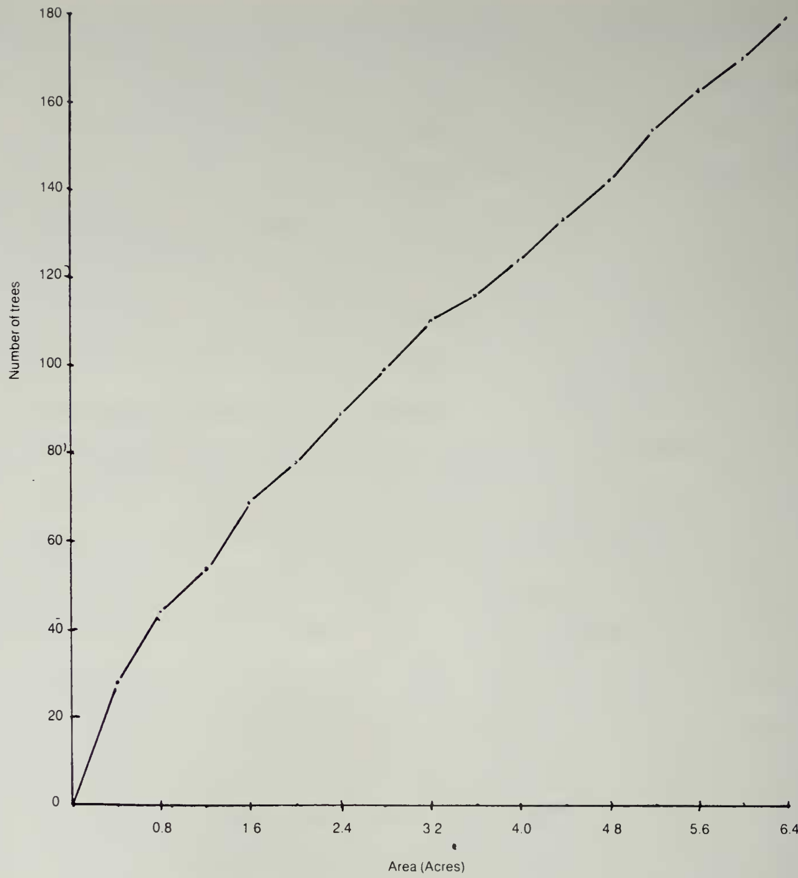

Fig. 3. Species/Area Curve. All trees with gbh>=24 inches.

notably by the Flora Malesiana Foundation, have also taken place. This has rendered some of the familiar and much used Latin names obsolete. In this study, not only have the identities of the plants been checked by the Singapore Botanic Gardens Herbarium, various relevant works have also been consulted to ensure the use of the latest Latin names. However, in order to enable foresters and plant ecologists of the Region, who might not have up-to-date knowledge of the plant names but are nevertheless familiar with old names, to get a quick mental comparison on what they read, I have wherever possible included such names in parentheses after the latest Latin names. This is done in both text and tables.

Appendix 1(b) gives a summary of the number of species and genera by family, with the families arranged in order of species preponderence. There are 44 known families and the totals show that the survey encountered 111 genera, 212 species and 889 individual trees. Apart from the 20 "unknown" trees there are another 20 trees in 11 genera which could be identified down to genus level only. That makes 849 trees which have been fully identified.

It can be seen that Euphorbiaceae has the highest number of genera (11) and the highest number of species (22). In terms of species preponderence the Burseraceae, Dipterocarpaceae, Myrtaceae and Lauraceae all tie second place with 13 species each! Next come Leguminosae with 11 species and Annonaceae with 10 species, and so on.

In terms of sample total the Dipterocarpaceae, with 125 individuals, tops the list. There is an anomaly in that the Theaceae takes second place with a sample total of 94 individuals. The species responsible for this is *Adinandra dumosa,* coming mainly from two clusters located in disturbed forest, namely clusters 25 and 26 (see Table 2). Surprisingly, the Sapotaceae also occupies a position of eminence, 5th in the list. This is due in the main to the fact that clusters 36 and 37 were located in a stand of planted *Palaquium gutta.* If we exclude these 4 stands from the analysis, then the two families in question would go further down in the list.

Barring the anomaly created by the 4 stands just referred to, one could say that the specific composition as encountered in Bukit Timah in the undisturbed stands is quite typical of the Lowland Dipterocarp Forest, of which the Coastal Hill Forest may be considered as a sub-type. As mentioned earlier, one of the outstanding features of the Coastal Hill Forest is the presence of *Shorea curtisii* (Seraya) at low elevation. In Bukit Timah its occurrence could be as low as 150 ft a.s.l. Associated with Seraya are usually such species as *Shorea gratissima, Shorea glauca, Dipterocarpus caudatus* ssp. *penangianus (D. penangianus) Anisoptera curtisii, Artocarpus lanceifolius, Swintonia schwenkii* or *S. spicifera.* With the exception of *Shorea glauca* these species are found within Bukit Timah but *Anisoptera curtisii* and *Swintonia* have not been netted in by our sample.

The dipterocarps have in this study shown family dominance, a fact which is quite well known from various studies made in Malaysia. In the Bukit Timah case this dominance is very much the result of two dipterocarp species, viz *Shorea curtisii,* with a total of 46 individuals, and *Dipterocarpus caudatus* ssp. *penangianus (D. penangianus)* with 37 individuals. These two dipterocarps alone have contributed 83 individuals out of a total of 125 (vide Appendix 1(a) & the end of Appendix 4).

Looking at Appendix 1(b) if we remove the two clusters located in the secondary forest dominated by *Adinandra dumosa,* then we would have the Euphorbiaceae taking the second place with a total of 70 individuals. It also has a preponderance of genera and species — with respectively 11 and 22 numbers. In terms of species, the genera *Aporusa* and *Baccaurea* contribute most to the total number. *Baccaurea kunstleri* and *Pimelodendron griffithianum* seem to be quite common and widespread. Unlike the dipterocarps, however, trees of the Euphorbiaceae are small. Even the larger ones have their crowns in the Main Storey of the canopy and many of them stay in the C storey. In our sample, probably the largest trees are *Endospermum diadenum (E. malaccense) Blumeodendron tokbrai* and *Baccaurea kunstleri,* all growing up to about 70 ft.

The Anacardiaceae follows closely behind the Euphorbiaceae in the preponderance of individuals with a sample total of 58, coming mainly from two species, viz *Gluta wallichii (Melanorrhoea woodsiana)* and *Campnosperma auriculatum,* respectively with 34 and 16 individuals. In Bukit Timah, it is somewhat surprising that the genus *Mangifera* is not as common as it should be. *Mangifera lagenifera,* for example, just like *Swintonia schwenkii,* is seen sporadically only in the Reserve, but our sample has not been able to net it in.

Campnosperma auriculatum is an interesting species in that it has a very wide ecological amplitude. It occurs in both primary and secondary forests, in the lowlands, in mountains and in the peat and fresh water swamps! Such a feat seems to be equalled only by *Koompassia malaccensis*(Leguminosae). In Bukit Timah, as in other places with high forest nearby *C. auriculatum* is one of the first pioneers to colonise secondary vegetation and in the primary jungles it can grow to a large emergent.

Gluta wallichii (Melanorrhoea woodsiana), apart from being abundant, is also the most wide spread species in Bukit Timah as the Distribution Index (see next

Section) will show, much to the woe of those who are allergic to its potent skin irritant! *Gluta wallichii,* unlike *Campnosperma,* is not a very large tree. Even when full grown its crown would be in the Main Storey of the canopy.

For more information on the relative importance of the various families and species in our sample, the reader is referred to the various parts of Appendix 1.

(c) Spatial Distribution of Species and the Distribution Index (DI)

From the *Mischungsquotient* mentioned earlier, it can be seen that the Bukit Timah forest, just like other Rain Forests in the Region, has a great diversity of species. Yet there can be no doubt that some species are of very low density while others show considerable dominance in numbers. Some species are vagrant while others tend to be more gregarious. In such a situation tabulation to show the presence of a species would not be too meaningful if we give only its sample total for it could mean that the individuals were present in only one or two sampling units, or they might be spread over many units. Because of this it is thought much more useful to present a comprehensive list of the plants showing both their sample totals as well as the extent to which they spread over the entire sample.

To show the latter phenomenon a parameter called the Distribution Index (DI) is used. The DI of a species is simply the number of sampling units in which it occurs. Thus, for example, in Appendix 1(a) it is seen that *Dipterocarpus caudatus* ssp. *penangianus (D. penangianus)* has a DI of 12. It simply means that in the whole sample, it occurs in 12 of the 20 clusters.

It has to be noted that it does not matter how many individuals occur in a cluster. So long as there is one individual of the species, the species scores 1 for that particular sampling unit. On the other hand even if there are 10 individuals in the unit the score for DI is still 1. This brings us to the other point which is important

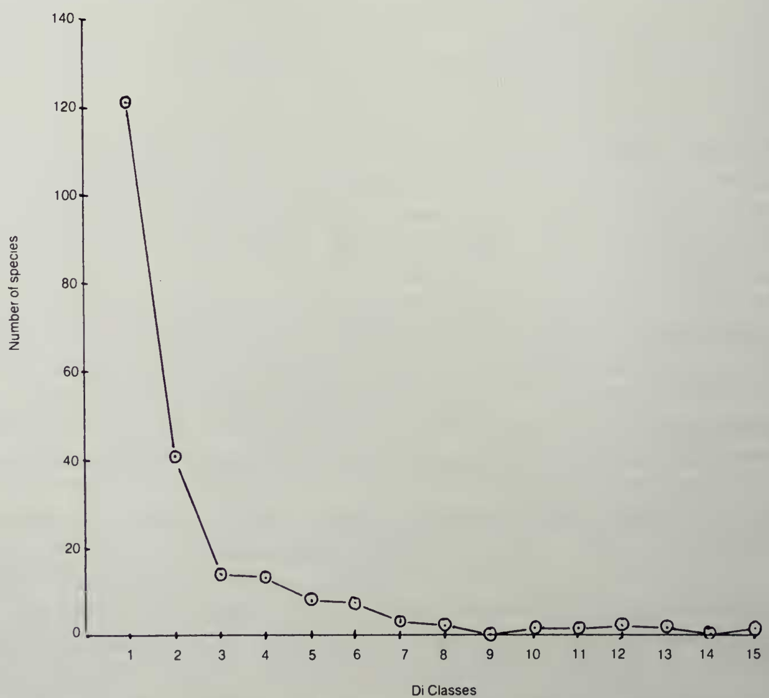

Fig. 4. Species Distribution & Distribution Index (DI). (See Section III(c) of text.)

for showing dominance, i.e. the sample total of a particular species. Taking *D. caudatus* ssp. *penangianus* again as an example, we find that its sample total from all the clusters adds up to 37. This is indeed a very high number compared with many other species. This, coupled with the fact that it is distributed in 12 of the 20 clusters, shows that it is wielding considerable influence within the community we have sampled.

Appendix 1(a) shows the DI amongst other things but much more information could be got at a glance by referring to Appendix 2. In here both sample total and the DI of a species are given with the DI indexed in ascending order. From here it can be seen that more than half of the species occur only once whereas others may occur in one cluster only but within that cluster it occurs 5 times. Such is the case with for example *Aporusa bracteosa* (Euphorbiaceae). Further, it can be seen that as DI increases the number of species drops rapidly (see Fig. 4). There are 121 species with DI=1 but when DI 7 is reached, there are only 3! These are *Pimelodendron griffithianum, Streblus elongatus (Sloetia elongata)* and *Timonius wallichianus.* Of the known species only 5 score a DI equal to or greater than 10. They are *Pellacalyx saccardianus* (10), *Artocarpus lanceifolius* (11), *Dipterocarpus caudatus* ssp. *penangianus* (12), *Shorea curtisii* (12) and *Gluta wallichii (Melanorrhoea woodsiana)* (15).

Species which have a DI of unity and small total, say 1 or 2 are likely to be isolated vagrants while those with a high DI and high total are the really common species of the community. A third condition can be that a species may have a low DI but a very high total. Such a case indicates an extremely gregarious condition and this may reflect the successional status of the particular community. Browsing through Appendix 2 one could discern such a condition for *Campnosperma auriculatum* (TOT 16, DI 3) *Rhodamnia cinerea (R. trinervia)* (TOT 16, DI 3) *Adinandra dumosa* (TOT 90, DI 4) *Palaquium gutta* (TOT 38, DI 4). In the case of *Campnosperma,* the master list (not included in this report) reveals that most of the individuals (some 11 numbers) come from Cluster 32 alone. Inspection of the list of species for the cluster shows that the associated species within that particular cluster are matured individuals of high forest species. But a closer scrutiny reveals that some 8 trees occur in Plot B alone within that cluster. It is therefore certain that Cluster 32 had been placed straddling the boundary between high and regenerating (disturbed) forest.

In the case of *Rhodamnia* and *Adinandra* most of the individuals have come from Clusters 25 and 26, which are located in disturbed vegetation. *Palaquium gutta,* as indicated previously, comes mainly from the historical planted patch within the Taban Valley.

(d) Structure of the Forest and Recruitment

For forest structure we shall use girth class distribution as an indicator. Appendix 2, *inter alia,* gives the girth class distribution of the various species and individuals encountered, from G1 to G6. The equivalents in inches are given below:

G1	G2	G3	G4	G5	G6
12-12.9	13-23.9	24-35.9	36-47.9	48-59.9	>=60.0

As mentioned in the notes on enumeration, G1 and G2 were only measured in the sub-sample of Plot A in each cluster. Appendix 2 has included all individuals down to G1.

Girth classes in a gigantic table are difficult to visualise. On account of this a graph is produced by plotting number of trees against girth classes. Before doing so

the data were re-arranged so that the girth classes extend from 12 inches gbh to over 144 inches gbh. As the 12-24 inch girth class was measured only in one of four sub-plots, the number obtained was extrapolated by multiplying by 4 so as to bring it in line with the other girth classes. The value of Girth Class 1 in Fig. 5 (796) has been obtained in this way.

The graph in Fig. 5 shows a typical inverted "J" for girth class distribution of individuals in a stand of uneven-aged forest. The characteristics are a very high number of small trees and a low number of very large trees.

The graph suggests that the forest as a whole is well stocked with young trees to take the place of the big giants when they die. This interpretation is likely to be an over-simplification. As is already known the forest is extremely mixed. The ecosystem is likely to be controlled by a fairly large number of species. For the present forest to beget a similar forest in the future, it is necessary to have species that form a large proportion of the present composition and which have vertical distribution

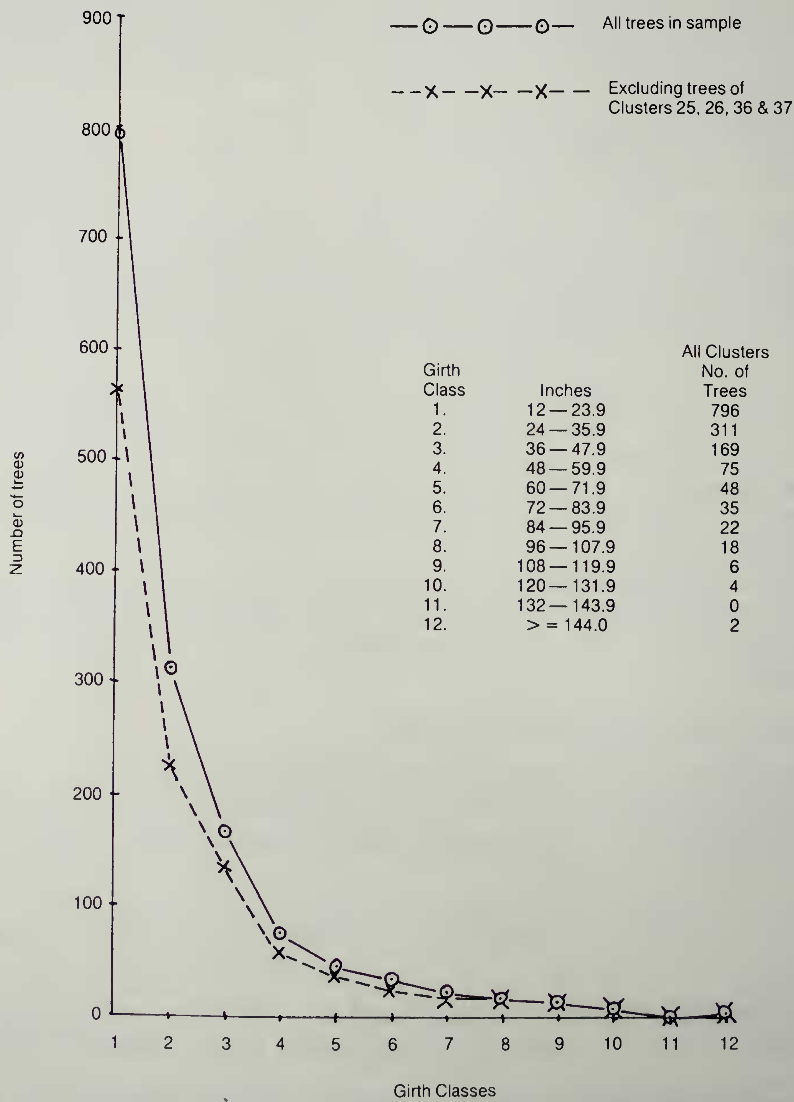

Fig. 5. Frequency Distribution in Different Girth Classes.

over the whole range of canopy strata. The data presented in the various sections in Appendix 3 are meant to afford a glimpse into this problem.

Each section presents the results of a command put to the computer to list the species with a definite girth class distribution pattern. In App. 3:a it was asked to display species which are represented in all girth classes. Only one species, *viz Streblus elongatus (Sloetia elongata)* met the condition. This species is likely to survive well under even adverse conditions. Not only does it have a high total, it also has a fairly high DI of 7, showing that it is fairly widely distributed. Indeed it is common knowledge that this species occurs in all kinds of vegetation and is one of the pioneers in regenerating forests.

App. 3:b lists species which have a continuous girth class distribution from G2 through to G6. For this 9 species meet the condition, including *Streblus* (*Sloetia*). It is interesting to note that practically all the species are high forest species and they are components of the different canopy strata — *Shorea curtisii, Dipterocarpus caudatus ssp. penangianus* and *Campnosperma auriculatum* are emergents; *Artocarpus lanceifolius, Gluta wallichii (Melanorrhoea woodsiana)* and *Artocarpus rigidus* are Main Storey species while the others are C-storey or Main Storey species. Moreover, for all of them G2+G3 are very strongly represented. These are trees with gbh from 13 inches to 36 inches. These are most likely to grow to maturity to take over from the present giants. There is yet another plus factor for this group of species, for it may be recalled that G1 & G2 were obtained using only 1 circular plot. Conceivably their numbers are much larger if we had sampled down to G1 in all the circular plots.

The total number of individuals in this group of trees number 241. Since *Palaquium gutta* comes from the planted plot we exclude its individuals. With this, 203 trees remain. The grand total for the whole sample is 889 trees. Taking proportion we can see that these few species contribute to over 22% of the total population. Not only that, with the exception of *Palaquium* and *Campnosperma,* they also have high DI's, indicating that they are widespread. They therefore exert considerable structural and other ecological influence on the community.

For App. 3:d the display is of species with a continuous girth class distribution from G4 to G6 and for this two more dipterocarps which are emergents and several more Main Storey species are included. Here we can discern species, *Shorea macroptera* and *Palaquium hexandrum,* which do not have small trees and we are apt to jump to the conclusion that they therefore lack a vital factor to back up their succession. However, this may not be necessarily so and this question is discussed further in the next Section.

IV. Discussion

The present study has confirmed that the forest at Bukit Timah Nature Reserve should best be considered as a Coastal Hill Forest according to Symington's classification (vide 1942, ibid) and as far as one could see a large proportion of the forest is still of a primary nature. However, although there was no organised commercial logging of the forest for timber, the significantly lower density of the forest compared with some stands in such a forest type in West Malaysia, gives rise to speculation that removal of small timbers by villagers living nearby could have taken place in the past. The average density of the forest at Bukit Timah is some 16% less than that of the Malaysian stands quoted in Table 1(b).

The forest at Bukit Timah is indeed rich dipterocarp forest with large trees of *Shorea curtisii* (Seraya) *Dipterocarpus caudatus ssp. penangianus* (Keruing) and many other trees of dipterocarps and non-dipterocarps which loggers would salivate over were they to see them in their concession area! Yet these giants seemed to

have escaped the saw. To hazard a guess one would say that one reason for their having done so lies perhaps in their not belonging to the groups of naturally durable heavy hardwood which loggers in the early days of timber utilisation sought after. Most of the large and common trees in Bukit Timah would yield what the wood technologist would classify as light or medium hardwood which found extensive uses only after the War on account of advancement in wood preservation. By that time, fortunately, Bukit Timah was already a nature reserve.

According to Symington, Coastal Hill Forest communities should have quite a number of Balaus (the Heavy Hardwood dipterocarps) such as *Shorea glauca* and *S. maxwelliana.* These, however, have not been met with during our enumeration nor did the writer see any outside the sample. Could their absence be due to past creaming? This is difficult to say but is unlikely for no sign of stumps could be seen nor would the very natural and undisturbed nature of the environment suggest past logging activities. Further, if such species had been in the forest before then although selective logging would have removed the large trees, their progeny could have survived in the forest and by now would have grown to sizeable individuals. Their absence therefore suggests that the forest is inherently lacking in such species.

Tropical Rain Forests are noted for their diversity of species. The present study shows that the forest at Bukit Timah is no exception. Indeed with *Mischungsquotients* ranging between 1.0 and 2.0 the forest is as diverse as any in Malaysia. Furthermore the stand curve derived has shown that the forest also has girth class distribution typical of uneven-aged stands. The characteristic inverted "J" indicates the presence of a very large number of small trees, quite numerous larger trees and a small number of very large trees.

Despite this, however, one of the nagging questions concerning a small area of forest like Bukit Timah (185 acres) which is completely isolated, is whether it could survive with unchanged character over a long period of time. The analysis in the previous Section has already touched briefly on this subject. Based on the evidence available it would appear quite a number of the high forest species show good recruitment and are well represented in the whole range of girth classes studied. On the other hand many of the giants have big trees only and are completely lacking in smaller progeny. One is apt to jump to the simple conclusion that those with smaller trees in say G1 to G3 are likely to survive while those without such small trees will be in danger of dying out. In actual fact the situation is likely to be much more complex and for a more complete picture, study of the seedling populations and of trees of different size classes of various species, under a continuous inventory with say annual reenumeration to assess changes in the populations, due to normal mortality and recruitment or to catastrophes, with time would be necessary. This of course would entail the laying down of permanent sampling units and labelling of the plants permanently.

The optimist may argue that the forest at Bukit Timah has been there for millennia and it has survived unchanged up to now despite its progressive isolation into a small plot of land in recent times. It is certainly true that based on its present composition, we can conclude that the forest is still similar to any other Coastal Hill Forest. Also even if it is true that species of emergents have no pole-sized trees at any one point in time that does not mean that there would not be such trees at a later date. The seedlings of *Shorea curtisii* (Seraya) are known to be able to grow up under their parents in rather shaded conditions and this may account for its superiority in numbers and continuous girth class distribution over a wide range of girth sizes (vide also Wong (1978)). On the other hand some species are known to have a truncated girth class distribution in nature, over a sizeable area of forest. Some of the emergents, e.g. *Shorea leprosula,* though needing forest conditions for

its saplings to grow up, are known to be light demanders and they need an opening in the canopy such as one resulting from the parent tree having been killed by a natural catastrophe, to give them the additional light and or reduction in root competition for growing up. If no disaster occurs over the area of forest in question to create the gaps, for a long, long time, then only large trees will appear in a sample. Poore (1968) has found in a lowland forest of 1 square kilometer in Jengka F.R. in Pahang, Malaysia, that 8 — 10% of the forest was under regeneration in some gaps. Further, he estimated that such gaps would take about 30 years to mature, i.e. to produce uniform crown conditions again to merge with the adjacent trees, and that such regenerated areas could last for a mean period of some 270 years! If this is so then uniform shaded conditions would prevail over this period and it would preclude the possibility of light demanding seedlings/saplings from growing up. It is little wonder therefore such species have a truncated girth class distribution.

The example just considered relates to a case of the habitat being taken over by the progeny of a tree formerly occupying it. However, this need not be always the case. Indeed it is doubtful when a forest dies it would be replaced by its replica. The demise of a big tree or group of trees could create conditions favourable for the progeny of nearby species to develop in the gap so created. It is entirely a matter of chance as to what would seed up, or grow up in, such a gap apart from saplings of the trees formerly occupying the site, as they might be there. Other factors being equal proximity of species to the gaps and an inherently more frequent fruiting habit, would definitely be an advantage. Thereafter the ensuing fierce competition will also determine what would survive and grow up to maturity.

It is most probable that such chanced reproduction of species in regeneration gaps in large ecosystems like the Lowland Dipterocarp Forest and the Peat Swamp Forest, is one way of ensuring species survival and hence species diversity. Enormity of area would ensure superiority in numbers for practically all species and hence a good chance for all to regenerate and survive. Thus although the composition of the forest and the pattern of species distribution may change from generation to generation, the same pool of species will remain practically unchanged.

The same mode of regeneration has been observed to take place in Bukit Timah but in a small isolated community it is likely that the innate ability of the species to regenerate and grow up in shade would be important for perpetuation. Perhaps it is no coincidence that the few species shown in Appendix 3: b have individuals in the whole range of girth class distribution and are numerically dominant as a group. Indeed they are the very species (perhaps with the exception of *Campnosperma*) that possess the innate quality of being able to reproduce and grow up in the shade and in the ambit of the parent trees.

Shorea curtisii, Anisoptera curtisii, Artocarpus lanceifolius are essentially Hill Forest species, in inland mountains occurring from about 1000 ft. to 2500 ft. a.s.l. in Malaysia. They miss the vast areas of Lowland Dipterocarp Forest only to emerge again in the Coastal Hills. Coastal Hills in contrast with inland mountain masses are always small. In this respect I would say that the forest at Bukit Timah, at least the typical Coastal Hill species viz *Shorea curtisii, Dipterocarpus caudatus* ssp. *penangianus, Anisoptera curtisii* and to some extent *Artocarpus lanceifolius,* have always faced isolation, even before the advent of Man as they could grow only in the Coastal Hill habitat in Singapore. Presumably the other species which are common to both Lowland Forest and the Coastal Hill Forest could have moved to and fro in geological time, thus contributing to and ensuring the complexity of their kinds; but not the few species just mentioned as they could only grow in the Hills. Granted that places like Mt Faber, Bukit Gombak and some of the hills in the Pasir Laba area, could have carried Coastal Hill species, knowing their characteristics they

could not have migrated to and fro to maintain their dominance in these places. In other words these species must have persisted as isolated colonies, and their innate ability to regenerate and grow up in the shade has ensured their survival and dominance.

Looked upon in this light it is likely that these species that wield structural dominance and to some extent numerical dominance (when considered as a group) would be able to persist in perpetuity, provided of course Bukit Timah is preserved. However, the physical isolation resulting from recent road and other development could induce more drastic fluctuations in the critically important ecological factors such as temperature and humidity. These may affect the periphery more but by and large they are not likely to have much effect on the interior of the Reserve bearing in mind that we are in the heart of the Humid Tropics. One thing though we must guard against and that is the danger of fire. During a very dry year the scrubland on the periphery may catch fire and this may cause destruction to the dried up interior of the forest. Such an event actually happened to Cape Rachado, another Coastal Hill Forest situated about 10 miles south of Port Dickson. The forest was badly burnt when it caught fire during the unusually dry spell of 1963. Many of the giant shoreas were killed and the place was invaded by *Trema* spp. For the other species on Bukit Timah which are common to both the Lowland Forest and the Coastal Hill Forest, particularly those with low frequencies and small DI's, the diminutive state of the Reserve does give cause for concern. For such species, the timing of a seed year or the presence of seedlings or small trees and the chance demise of the parent tree is very critical. This is particularly so when it is realised that most of the large trees in the Rain Forest have evolved with long fruiting intervals of 2, 3 and as long as, 7 years. For a small, isolated forest like Bukit Timah the scenario as depicted below could happen.

Let us say a *Dyera costulata,* the Jelutong, (of which there are only a few individuals in the Reserve) has no seedlings on the ground now. Neither are there pole-sized trees around. It is killed by lightning. That could be the end of that tree and species in that particular spot. Since the Reserve is small and since the population of such a species is finite it is conceivable that after a few more of such disasters, the species is extinct within the Reserve. This is the kind of mechanism that could in the long run lead to retrogressive changes in the specific composition of the forest, resulting in the decline in the number of species. Unlike the geological past, before the advent of Man, there shall not be Jelutong trees near Bukit Timah to effect migration back to it!

To conclude I think we can say that Bukit Timah is unique in that at the fringe of a great metropolis lies the relict of a small Rain Forest community completely isolated by non-forested areas. Ecologically it should be extremely interesting to study. Scientific records obtained under a continuous inventory over the next decade or two should yield preliminary information on changes in the community with its component small animals one way or another. Would it be able to survive with no loss in characteristics or would it degenerate into a secondary forest such as many experts have predicted. Only time and some hard work will tell.

Acknowledgement

As mentioned in the introduction the field work of the project was carried out as an activity of the Singapore Branch of the Malayan Nature Society. At the time the Secretary was Mrs Lisette Henrey. She and her husband were indeed staunch supporters. This could be seen from the fact that Mr. Henrey had on many occasions come with their toddler kid tied to his back Chinese style to help in the enumeration! Other regular supporters were Prof. A.N. Rao of the Botany Department, University of Singapore, and his colleagues, notably Prof. Hsuan Keng, and

Dr. K.H. Chow, my then colleagues Lee Sing Kong & Teoh Teck Seng, and students of the Ornamental School of Horticulture, Botanic Gardens. Occasionally we were also joined by some other members of the Malayan Nature Society of whom it will be too numerous to mention by names and to whom I should like to express my grateful thanks for having helped in the field work.

I am also very much indebted to Mohd. Shah of the Botanic Gardens for having assisted in the identification of materials in the herbarium. If not for his painstaking work the magnitude of the "Unknown" in our plant lists would have been much larger. He and Ali Ibrahim also helped to up-date the Latin names of many of the species and the authorities that go with them.

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Appendix 1: a. Complete list of species (gbh>=12″) by family, with the species' sample totals and their distribution indices (DI).

(For explanation on DI see text Sect. III (c). Latin names in parentheses are obsolete but familiar names.)

Rec.#	Family	Species	Total	DI
1.	ANACAR	Bouea macrophylla Griff.	1	1
2.	ANACAR	Bouea oppositifolia (Roxb.) Meissn.	1	1
3.	ANACAR	Buchanania sessilifolia Bl.	2	2
4.	ANACAR	Campnosperma auriculatum (Bl.) Hk. f.	16	3
5.	ANACAR	Gluta wallichii (Hk. f.) Ding Hou (Melanorrhoea woodsiana King)	34	15
6.	ANACAR	Parishia paucijuga Engl.	4	4
7.	ANONA	Anaxagorea javanica Bl.	1	1
8.	ANONA	Cyathocalyx ramuliflorus (Maing. ex Hk. f & Th.) Scheff.	7	6
9.	ANONA	Cyathocalyx ridleyi (King) Sinclair	1	1
10.	ANONA	Fissistigma lanuginosum Hk. f. et Th.	2	1
11.	ANONA	Fissistigma latifolium (Duval) Merr.	1	1
12.	ANONA	Polyalthia hookeriana King	1	1
13.	ANONA	Polyalthia rumphii (Bl.) Merr.	2	1
14.	ANONA	Polyalthia sp.	2	1
15.	ANONA	Xylopia ferruginea (Hk. f. et Th.) Hk. f. et Th.	1	1
16.	ANONA	Xylopia malayana Hk. f. et Th.	2	2
17.	APOCYN	Alstonia angustifolia Wall. ex A.DC.	1	1
18.	APOCYN	Dyera costulata (Miq.) Hk. f.	1	1
19.	BOMBAC	Durio griffithii (Mast.) Bakh.	1	1
20.	BURSER	Canarium grandifolium (Ridl.) H.J. Lam	1	1
21.	BURSER	Canarium sp.	1	1
22.	BURSER	Dacryodes costata (Benn.) H.J. Lam	2	1
23.	BURSER	Dacryodes laxa var typica (Benn.) H.J. Lam	2	2
24.	BURSER	Dacryodes rostrata (Bl.) H.J. Lam	2	2
25.	BURSER	Dacryodes rugosa (Bl.) H.J. Lam	1	1
26.	BURSER	Santiria apiculata Benn.	2	1
27.	BURSER	Santiria griffithii (Hk. f.) Engl.	12	8
28.	BURSER	Santiria laevigata Bl.	8	8
29.	BURSER	Santiria rubiginosa Bl.	5	4
30.	BURSER	Santiria tomentosa Bl.	3	2
31.	BURSER	Santiria sp. A	1	1
32.	BURSER	Santiria sp. B	1	1
33.	CELAST	Bhesa paniculata Arn.	4	2
34.	CELAST	Kokoona reflexa (Laws.) Ding Hou (Lophopetalum reflexum Laws.)	1	1
35.	CONNAR	Agelaea borneensis (Hk. f.) Merr.	1	1
36.	CONNAR	Ellipanthus tomentosus kurz	1	1
37.	DILLEN	Dillenia grandifolia Wall. ex Hk. f. et Th. (Dillenia eximia Miq.)	2	2
38.	DIPTER	Anisoptera costata Korth.	1	1
39.	DIPTER	Dipterocarpus kerrii king	5	3
40.	DIPTER	Dipterocarpus caudatus ssp. penangianus (Foxw.) Ashton (Dipterocarpus penangianus Foxw.)	37	12
41.	DIPTER	Dipterocarpus sublamellatus Foxw.	3	1
42.	DIPTER	Hopea mengarawan Miq.	4	4

(Appendix 1:a cont.)

Rec.#	Family	Species	Total	DI
43.	DIPTER	Shorea bracteolata Dyer	1	1
44.	DIPTER	Shorea curtisii Dyer ex King	46	12
45.	DIPTER	Shorea gratissima (Wall. ex Kurz.) Dyer	3	2
46.	DIPTER	Shorea leprosula Miq.	10	5
47.	DIPTER	Shorea macroptera Dyer	4	3
48.	DIPTER	Shorea pauciflora King	9	6
49.	DIPTER	Vatica maingayi Dyer	1	1
50.	DIPTER	Vatica sp. A	1	1
51.	EBENA	Diospyros buxifolia (Bl.) Hiern	2	2
52.	EBENA	Diospyros lanceifolia Roxb.	1	1
53.	EBENA	Diospyros maingayi (Hiern) Bakh.	1	1
54.	EBENA	Diospyros sp.	1	1
55.	ELAEOC	Elaeocarpus acronodia Bl. (Elaeocarpus mastersii King)	2	2
56.	ELAEOC	Elaeocarpus nitidus Jack	2	1
57.	ELAEOC	Elaeocarpus petiolatus Wall.	1	1
58.	ELAEOC	Elaeocarpus polystachyus Wall.	1	1
59.	EUPHOR	Antidesma coriaceum Tul.	3	3
60.	EUPHOR	Antidesma cuspidatum Muell. Arg.	1	1
61.	EUPHOR	Aporusa benthamiana Hk. f.	2	2
62.	EUPHOR	Aporusa bracteosa Pax. et Hoffm.	5	1
63.	EUPHOR	Aporusa prainiana King ex Gage	1	1
64.	EUPHOR	Aporusa sp. A	1	1
65.	EUPHOR	Aporusa sp. B	1	1
66.	EUPHOR	Baccaurea bracteata Muell. Arg.	2	2
67.	EUPHOR	Baccaurea kunstleri King ex Gage	9	5
68.	EUPHOR	Baccaurea maingayi Hk. f.	2	2
69.	EUPHOR	Baccaurea sumatrana Miq.	6	5
70.	EUPHOR	Baccaurea sp. A	2	2
71.	EUPHOR	Baccaurea sp. B	1	1
72.	EUPHOR	Blumeodendron tokbrai (Bl.) Kurz	5	4
73.	EUPHOR	Elateriospermum tapos Bl.	2	2
74.	EUPHOR	Endospermum diadenum (Miq.) Airy Shaw (Endospermum malaccense Muell. Arg.)	4	4
75.	EUPHOR	Koilodepas longifolium Hk. f.	1	1
76.	EUPHOR	Macaranga conifera (Zoll.) Muell. Arg.	2	1
77.	EUPHOR	Macaranga lowii King ex Hk. f.	1	1
78.	EUPHOR	Mallotus penangensis Muell. Arg.	5	1
79.	EUPHOR	Pimelodendron griffithianum (Muell. Arg.) Benth.	9	7
80.	EUPHOR	Ptychopyxis caput-medusae (Hk. f.) Ridl.	5	2
81.	FAGA	Castanopsis megacarpa Gamb.	1	1
82.	FAGA	Castanopsis wallichii King ex Hk. f.	1	1
83.	FAGA	Castanopsis sp.	1	1
84.	FAGA	Lithocarpus conocarpus (Oudem.) Rehd.	2	2
85.	FAGA	Lithocarpus encleisacarpus (Korth) A. Camus	3	3
86.	FAGA	Lithocarpus ewyckii (Korth) Rehd.	2	1
87.	GUTTIF	Calophyllum curtisii King	3	2
88.	GUTTIF	Calophyllum ferrugineum Ridl.	4	4
89.	GUTTIF	Calophyllum pulcherrimum Wall. ex Planch. et Triana	4	3
90.	GUTTIF	Calophyllum rubiginosum Hend. et Wyatt-Smith	2	1

(Appendix 1:a cont.)

Rec.#	Family	Species	Total	DI
91.	GUTTIF	Calophyllum wallichianum Planch. et Triana	1	1
92.	GUTTIF	Garcinia hombroniana Pierre	2	2
93.	GUTTIF	Garcinia nigrolineata Planch. et T. Anders.	2	2
94.	GUTTIF	Garcinia rostrata (Hassk.) Miq.	1	1
95.	HYPERI	Cratoxylon formosum (Jack) Dyer	3	3
96.	IXONAN	Ixonanthes icosandra Jack	4	4
97.	IXONAN	Ixonanthes reticulata Jack	20	6
98.	LAURA	Actinodaphne malaccensis Hk. f.	1	1
99.	LAURA	Actinodaphne sesquipedalis Hk. f. et Th. ex Meissn.	1	1
100.	LAURA	Beilschmiedia maingayi Hk.f.	3	3
101.	LAURA	Cinnamomum zeylanicum Garc. ex Bl.	1	1
102.	LAURA	Cryptocarya ferrea Bl.	1	1
103.	LAURA	Crytocarya rugulosa Hk. f.	1	1
104.	LAURA	Litsea castanea Hk. f.	8	5
105.	LAURA	Litsea costalis (Bl.) Kosterm.	1	1
106.	LAURA	Litsea elliptica Bl.	3	3
107.	LAURA	Litsea gracilipes Hk. f.	1	1
108.	LAURA	Litsea grandis Hk. f.	2	1
109.	LAURA	Litsea machilifolia Gamb.	2	2
110.	LAURA	Nothaphoebe umbelliflora (Bl.) Bl.	1	1
111.	LEGUMI	Dialum kingii Prain.	4	3
112.	LEGUMI	Dialium laurinum Baker	2	2
113.	LEGUMI	Dialium maingayi Baker	1	1
114.	LEGUMI	Dialium patens Baker	2	1
115.	LEGUMI	Dialium platysepalum Baker	3	1
116.	LEGUMI	Dialium wallichii Prain	2	1
117.	LEGUMI	Koompassia malaccensis Maing. ex Benth.	10	6
118.	LEGUMI	Sindora coriacea Maing. ex Prain	1	1
119.	LEGUMI	Sindora echinocalyx (Benth.) Prain	1	1
120.	LEGUMI	Sindora velutina Baker	1	1
121.	LEGUMI	Sindora sp.	1	1
122.	MAGNOL	Aromadendron elegans Bl.	2	2
123.	MELAST	Memecylon coeruleum Jack	1	1
124.	MELAST	Pternandra coerulescens Jack	2	2
125.	MELAST	Pternandra echinata Jack	7	5
126.	MELIA	Aglaia trichostemon C. DC.	2	2
127.	MELIA	Aglaia sp.	2	2
128.	MELIA	Chisocheton erythrocarpus Hiern.	1	1
129.	MELIA	Dysoxylon sp.	5	1
130.	MELIA	Sandoricum koetjape (Burm. f.) Merr.	1	1
131.	MORA	Artocarpus kemando Miq.	1	1
132.	MORA	Artocarpus lanceifolius Roxb.	14	11
133.	MORA	Artocarpus rigidus Bl.	9	6
134.	MORA	Artocarpus scortechinii King	5	4
135.	MYRIST	Gymnacranthera eugeniifolia (A. DC.) Sincl.	2	2
136.	MYRIST	Gymnacranthera forbesii (King) Warb.	1	1
137.	MYRIST	Horsfieldia brachiata (King) Warb.	1	1
138.	MYRIST	Horsfieldia superba (Hk. f. & Th.) Warb.	1	1
139.	MYRIST	Knema hookeriana (Hk. f. et Th.) Warb.	1	1
140.	MYRIST	Knema intermedia (Bl.) Warb.	1	1
141.	MYRIST	Myristica cinnamomea King	2	2
142.	MYRSIN	Ardisia tuberculata Wall.	2	1
143.	MYRSIN	Ardisia teysmanniana Scheff.	1	1

(Appendix 1:a cont.)

Rec.#	Family	Species	Total	DI
144.	MYRSIN	Maesa ramentacea Wall.	1	1
145.	MYRTA	Eugenia chlorantha Duthie	1	1
146.	MYRTA	Eugenia filiformis Duthie	3	2
147.	MYRTA	Eugenia glauca King	1	1
148.	MYRTA	Eugenia linocieroidea King	5	2
149.	MYRTA	Eugenia ngadimaniana Hend.	2	2
150.	MYRTA	Eugenia palembanica (Miq.) Merr.	2	1
151.	MYRTA	Eugenia rugosa (Korth) Merr.	5	5
152.	MYRTA	Eugenia subdecussata Duthie	4	2
153.	MYRTA	Eugenia sp. A	2	2
154.	MYRTA	Eugenia sp. B	2	2
155.	MYRTA	Eugenia sp. C	2	1
156.	MYRTA	Rhodamnia cinerea Jack (Rhodamnia trinervia Bl.)	16	3
157.	MYRTA	Tristania merguensis Griff.	1	1
158.	OCHNA	Gomphia serrata (Gaertn.) Kanis	2	1
159.	OLACA	Ochanostachys amentacea Mast.	5	5
160.	OLACA	Scorodocarpus borneensis Becc.	5	4
161.	OLACA	Strombosia ceylanica Gardn. (Strombosia rotundifolia King)	1	1
162.	POLYGA	Xanthophyllum ellipticum Korth. ex Miq. (Xanthophyllum kingii Chodat)	1	1
163.	POLYGA	Xanthophyllum stipitatum Benn.	4	4
164.	POLYGA	Xanthophyllum sp.	1	1
165.	RHAMNA	Ziziphus calophylla Wall.	1	1
166.	RHIZO	Gynotroches axillaris Bl.	6	5
167.	RHIZO	Pellacalyx axillaris Korth.	1	1
168.	RHIZO	Pellacalyx saccardianus Scort.	28	10
169.	ROSA	Licania splendens (Korth.) Prance	1	1
170.	ROSA	Prunus polystachya (Hk. f.) Kalkman	1	1
171.	RUBIA	Pertusadina eurhyncha (Miq.) Ridsdale (Adina rubescens Hemsl.)	1	1
172.	RUBIA	Diplospora malaccensis Hk. f.	1	1
173.	RUBIA	Nauclea officinalis (Pierre ex Pitard) Merr. et Chun. (Nauclea junghuhnii Merr.)	2	2
174.	RUBIA	Randia densiflora Benth.	6	1
175.	RUBIA	Randia scortechinii King & Gamb.	13	6
176.	RUBIA	Timonius wallichianus (Korth.) Valeton	13	7
177.	RUBIA	Urophyllum glabrum Wall. ex Roxb.	1	1
178.	RUTA	Euodia glabra (Bl.) Bl. (Evodia glabra Bl.)	5	2
179.	SABIA	Meliosma pinnata (Roxb.) Walp	2	2
180.	SAPIND	Nephelium glabrum Noronoh	2	1
181.	SAPIND	Nephelium lappaceum L.	2	2
182.	SAPIND	Euphoria malaiensis (Griff.) Radlk. (Nephelium malaiense Griff.)	1	1
183.	SAPIND	Nephelium rubescens Hiern	1	1
184.	SAPIND	Nephelium sp.	1	1
185.	SAPIND	Pometia pinnata Forst. f. alnifolia (Bl.) Jacobs.	2	1
186.	SAPIND	Xerospermum intermedium Radlk.	1	1
187.	SAPOTA	Ganua kingiana (Brace) van den Assem	4	3
188.	SAPOTA	Palaquium gutta (Hk.f.) Baillon	38	4

(Appendix 1:a cont.)

Rec.#	Family	Species	Total	DI
189.	SAPOTA	Palaquium hexandrum (Griff.) Baillon	4	1
190.	SAPOTA	Palaquium microphyllum King & Gamb.	2	2
191.	SAPOTA	Palaquium obovatum (Griff.) Engl.	2	2
192.	SAPOTA	Palaquium semaram H.J. Lam	6	6
193.	SAPOTA	Payena obscura Burck	1	1
194.	SAPOTA	Planchonella maingayi (Clarke) van Royen	1	1
195.	SIMARU	Eurycoma longifolia Jack	1	1
196.	STERCU	Heritiera elata Ridl.	2	2
197.	STERCU	Scaphium macropodum (Miq.) Beumee ex Heyne (Scaphium affine Miq.)	1	1
198.	STERCU	Heritiera simplicifolia (Mast.) Kosterm. (Tarrietia simplicifolia Mast.)	1	1
199.	THEA	Adinandra acuminata Korth.	1	1
200.	THEA	Adinandra dumosa Jack	90	4
201.	THEA	Ploiarium alternifolium (Vahl) Melchior	1	1
202.	THEA	Ternstroemia bancana Miq.	1	1
203.	THEA	Gordonia multinervis King	1	1
204.	THEA	Gordonia singaporeana Wall. ex Ridl.	1	1
205.	THYMEL	Aquilaria malaccensis Lamk.	1	1
206.	TILIA	Grewia blattaefolia Corner	5	3
207.	TILIA	Pentace triptera Mast.	3	2
208.	MORA	Ficus dubia Wall. ex King	1	1
209.	ULMA	Gironniera nervosa Planch.	4	3
210.	ULMA	Gironniera parvifolia Planch.	8	5
211.	ULMA	Streblus elongatus (Miq.) Corner (Sloetia elongata (Miq.) Koord.)	19	7
212.	VERBEN	Teijsmanniodendron coriaceum (Clarke) Kosterm.	2	1
213.		Unknown	20	13

Appendix 1: b. Families arranged according to descending order of species preponderence.
(All species with gbh > = 12 inches)

	Family	No. of Genera	No. of Species	Sample Total
1.	Euphorbiaceae	11	22	70
2.	Burseraceae	3	13	41
3.	Dipterocarpaceae	5	13	125
4.	Myrtaceae	3	13	46
5.	Lauraceae	6	13	26
6.	Leguminosae	3	11	28
7.	Anonaceae	5	10	20
8.	Guttiferae	2	8	19
9.	Sapotaceae	4	8	58
10.	Sapindaceae	4	7	10
11.	Myristicaceae	4	7	9
12.	Rubiaceae	6	7	37
13.	Fagaceae	2	6	10
14.	Moraceae	3	6	49
15.	Anacardiaceae	5	6	58
16.	Theaceae	3	5	94
17.	Meliaceae	4	5	11
18.	Elaeocarpaceae	1	4	6
19.	Ebenaceae	1	4	5
20.	Melastomaceae	2	3	10
21.	Sterculiaceae	2	3	4
22.	Myrisinaceae	2	3	4
23.	Rhizophoraceae	2	3	35
24.	Olacaeae	3	3	11
25.	Polygalaceae	1	3	6
26.	Ixonanthaceae	1	2	24
27.	Ulmaceae	1	2	12
28.	Connaraceae	2	2	2
29.	Rosaceae	2	2	2
30.	Apocynaceae	2	2	2
31.	Tiliaceae	2	2	7
32.	Celastraceae	2	2	5
33.	Rutaceae	1	1	5
34.	Hypericaceae	1	1	3
35.	Sabiaceae	1	1	2
36.	Verbenaceae	1	1	2
37.	Ochnaceae	1	1	2
38.	Dilleniaceae	1	1	2
39.	Magnoliaceae	1	1	2
40.	Bombacaceae	1	1	1
41.	Rhamnaceae	1	1	1
42.	Simarubaceae	1	1	1
43.	Ternstroemiaceae	1	1	1
44.	Thymeliaceae	1	1	1
45.	Unknown	0	0	10
	Total:	111	212	889

Appendix 2. Girth class distribution and spatial distribution of species as indicated by the Distribution Index (DI).

All species with girth>=12".
G1 & G2 obtained from only 1 of 4 sub-plots of each cluster.
For explanation on DI and girth size (G) equivalents see Sect. III (c) & III (d).
"TOT" is the Sample Total of the Species

	Species	Code	G1	G2	G3	G4	G5	G6	TOT	DI
1.	Actinodaphne malaccensis	ACMA	0	1	0	0	0	0	1	1
2.	Actinodaphne sesquipedalis	ACSE	0	0	1	0	0	0	1	1
3.	Adinandra acuminata	ADIN	0	0	0	0	1	0	1	1
4.	Agelaea trinervia	AGET	0	0	1	0	0	0	1	1
5.	Alstonia angustifolia	ALAN	0	1	0	0	0	0	1	1
6.	Anaxagorea javanica	ANAX	0	0	0	1	0	0	1	1
7.	Anisoptera costata	ANIS	0	0	0	1	0	0	1	1
8.	Antidesma cuspidatum	ANTC	0	0	1	0	0	0	1	1
9.	Aporusa bracteosa	APBR	1	2	2	0	0	0	5	1
10.	Aporusa prainiana	APPR	0	0	0	1	0	0	1	1
11.	Aporusa sp. A	APZA	1	0	0	0	0	0	1	1
12.	Aporusa sp. B	APZB	0	0	1	0	0	0	1	1
13.	Aquilaria malaccensis	AQMA	0	0	0	0	0	1	1	1
14.	Ardisia teysmanniana	ARDT	0	0	1	0	0	0	1	1
15.	Ardisia tuberculata	ARDI	0	1	1	0	0	0	2	1
16.	Artocarpus kemando	ARKE	0	0	0	1	0	0	1	1
17.	Baccaurea sp. B	BAZB	1	0	0	0	0	0	1	1
18.	Bouea macrophylla	BOMA	0	0	1	0	0	0	1	1
19.	Bouea oppositifolia	BOOP	0	0	0	1	0	0	1	1
20.	Calophyllum rubiginosum	CALR	0	2	0	0	0	0	2	1
21.	Calophyllum wallichianum	CALW	0	0	0	0	1	0	1	1
22.	Canarium grandifolium	CANA	0	0	0	1	0	0	1	1
23.	Canarium sp	CANP	0	1	0	0	0	0	1	1
24.	Castanopsis megacarpa	CASM	0	0	0	0	1	0	1	1
25.	Castanopsis wallichii	CAST	0	0	0	1	0	0	1	1
26.	Castanopsis sp.	CAZP	0	0	0	1	0	0	1	1
27.	Chisocheton erythrocarpus	CHER	0	1	0	0	0	0	1	1
28.	Cinnamomum zeylanicum	CIZE	0	0	0	1	0	0	1	1
29.	Cryptocarya ferrea	CRFE	0	0	0	1	0	0	1	1
30.	Cryptocarya rugulosa	CRRU	0	1	0	0	0	0	1	1
31.	Cyathocalyx ridleyi	CYRI	0	0	1	0	0	0	1	1
32.	Dacryodes costata	DACO	0	0	1	1	0	0	2	1
33.	Dacryodes rugosa	DARU	0	1	0	0	0	0	1	1
34.	Dialium maingayi	DIMA	0	0	1	0	0	0	1	1
35.	Dialium patens	DIPA	0	0	1	0	1	0	2	1
36.	Dialium platysepalum	DIPL	0	1	1	0	0	1	3	1
37.	Dialium wallichii	DIWA	0	0	0	0	0	2	2	1
38.	Diospyros lanceifolia	DOLA	0	0	0	1	0	0	1	1
39.	Diospyros maingayi	DOMA	0	0	1	0	0	0	1	1
40.	Diospyros sp.	DOSP	0	0	0	0	0	1	1	1
41.	Diplospora malaccensis	DPMA	0	0	0	0	1	0	1	1
42.	Dipterocarpus sublamellatus	DPRS	0	0	3	0	0	0	3	1
43.	Durio griffithii	DUGR	0	1	0	0	0	0	1	1
44.	Dyera costulata	DYCO	0	1	0	0	0	0	1	1
45.	Dysoxylon sp.	DYSP	0	4	1	0	0	0	5	1
46.	Elaeocarpus nitidus	ELAN	0	0	0	2	0	0	2	1
47.	Elaeocarpus petiolatus	ELAP	0	0	0	1	0	0	1	1
48.	Elaeocarpus polystachyus	ELAS	1	0	0	0	0	0	1	1

(Appendix 2 contd.)

	Species	Code	G1	G2	G3	G4	G5	G6	TOT	DI
49.	Ellipanthus tomentosus	ELTO	0	0	1	0	0	0	1	1
50.	Eugenia chlorantha	EUCH	0	1	0	0	0	0	1	1
51.	Eugenia glauca	EUGL	0	1	0	0	0	0	1	1
52.	Eugenia palembanica	EUPA	0	2	0	0	0	0	2	1
53.	Eugenia sp. C	EUZD	0	0	2	0	0	0	2	1
54.	Euphoria malaiensis	NEMA	1	0	0	0	0	0	1	1
55.	Eurycoma longifolia	EVLO	0	0	1	0	0	0	1	1
56.	Ficus dubia	FICD	0	0	0	0	0	1	1	1
57.	Fissistigma lanuginosum	FILA	0	0	1	1	0	0	2	1
58.	Fissistigma latifolium	FILT	0	0	1	0	0	0	1	1
59.	Garcinia rostrata	GARR	0	0	0	1	0	0	1	1
60.	Gomphia serrata	GOMS	0	0	2	0	0	0	2	1
61.	Gordonia multinervis	GOMU	0	0	0	0	0	1	1	1
62.	Gordonia singaporeana	GOSI	0	0	0	1	0	0	1	1
63.	Gymnacranthera forbesii	GYFO	0	0	1	0	0	0	1	1
64.	Horsfieldia brachiata	HORB	0	1	0	0	0	0	1	1
65.	Horsfieldia superba	HOSU	0	0	1	0	0	0	1	1
66.	Knema hookeriana	KNHO	0	0	1	0	0	0	1	1
67.	Knema intermedia	KNIN	0	1	0	0	0	0	1	1
68.	Koilodepas longifolium	KOLO	0	1	0	0	0	0	1	1
69.	Kokoona reflexa	LORE	0	0	0	1	0	0	1	1
70.	Licania splendens	LICA	0	0	0	0	1	0	1	1
71.	Lithocarpus ewyckii	LIEW	0	0	1	1	0	0	2	1
72.	Litsea costalis	LITC	0	0	0	1	0	0	1	1
73.	Litsea gracilipes	LITG	0	0	1	0	0	0	1	1
74.	Litsea grandis	LITN	0	0	0	1	1	0	2	1
75.	Macaranga conifera	MACO	0	0	0	0	2	0	2	1
76.	Macaranga lowii	MALO	0	1	0	0	0	0	0	1
77.	Mallotus penangensis	MAPE	1	3	0	0	1	0	5	1
78.	Maesa ramentacea	MARA	0	1	0	0	0	0	1	1
79.	Memecylon coeruleum	MECO	0	0	1	0	0	0	1	1
80.	Meliosma pinnata	MEPI	0	1	1	0	0	0	2	1
81.	Nephelium glabrum	NEGL	0	0	1	1	0	0	2	1
82.	Nephelium rubescens	NERU	0	0	0	1	0	0	1	1
83.	Nephelium sp.	NESP	0	0	1	0	0	0	1	1
84.	Nothaphoebe umbelliflora	NOUM	0	1	0	0	0	0	1	1
85.	Palaquium hexandrum	PAHE	0	0	0	2	1	1	4	1
86.	Payena obscura	PAYA	0	0	0	0	0	1	1	1
87.	Pellacalyx axillaris	PEAX	0	0	0	0	0	1	1	1
88.	Pertusadina eurhyncha	ADIA	0	0	0	0	0	1	1	1
89.	Ploiarium alternifolium	PLAL	0	0	1	0	0	0	1	1
90.	Planchonella maingayi	PLMA	0	0	0	0	0	1	1	1
91.	Polyalthia hookeriana	POHO	0	0	1	0	0	0	1	1
92.	Polyalthia rumphii	POLR	0	0	1	1	0	0	2	1
93.	Polyalthia sp.	POLS	0	2	0	0	0	0	2	1
94.	Pometia pinnata f. alnifolia	POMA	0	0	0	0	0	2	2	1
95.	Prunus polystachya	PRPO	0	0	0	0	0	1	1	1
96.	Randia densiflora	RADE	1	3	2	0	0	0	6	1
97.	Sandoricum koetjapi	SAND	0	0	0	1	0	0	1	1
98.	Santiria apiculata	SANE	1	1	0	0	0	0	2	1
99.	Santiria sp. A	SAZA	0	0	0	1	0	0	1	1
100.	Santiria sp. B	SAZB	0	0	1	0	0	0	1	1
101.	Scaphium macropodum	SCAF	0	0	1	0	0	0	1	1
102.	Shorea bracteolata	SHBR	0	0	0	0	0	1	1	1
103.	Sindora coriacea	SICO	0	0	0	1	0	0	1	1
104.	Sindora echinocalyx	SIEC	0	0	1	0	0	0	1	1

(Appendix 2 contd.)

	Species	Code	G1	G2	G3	G4	G5	G6	TOT	DI
105.	Sindora velutina	SIVE	0	0	0	1	0	0	1	1
106.	Sindora sp.	SIZP	0	0	0	0	0	1	1	1
107.	Strombosia ceylanica	STRO	0	0	1	0	0	0	1	1
108.	Heritiera simplicifolia	TASI	0	0	0	0	0	1	1	1
109.	Ternstroemia bancana	TEBA	0	0	0	1	0	0	1	1
110.	Teijsmanniodendron coriaceum	TJCO	0	2	0	0	0	0	2	1
111.	Tristania merguensis	TRME	0	0	0	0	0	1	1	1
112.	Urophyllum glabrum	URGL	0	1	0	0	0	0	1	1
113.	Vatica maingayi	VASA	0	0	1	0	0	0	1	1
114.	Vatica sp. A	VASB	0	1	0	0	0	0	1	1
115.	Xanthophyllum ellipticum	XAKI	0	0	0	1	0	0	1	1
116.	Xanthophyllum sp.	XAZP	0	0	0	1	0	0	1	1
117.	Xerospermum intermedium	XEIN	0	0	0	1	0	0	1	1
118.	Xylopia ferruginea	XYFE	0	0	0	1	0	0	1	1
119.	Ziziphus calophylla	ZICA	0	0	1	0	0	0	1	1
120.	Aglaia trichostemon	AGLT	0	0	0	1	1	0	2	2
121.	Aglaia sp.	AGSP	0	0	2	0	0	0	2	2
122.	Aporusa benthamiana	APBE	0	0	1	1	0	0	2	2
123.	Aromadendron elegans	AREL	1	0	0	0	0	1	2	2
124.	Baccaurea bracteata	BABR	1	0	1	0	0	0	2	2
125.	Baccaurea maingayi	BAMA	0	0	2	0	0	0	2	2
126.	Baccaurea sp. A	BAZA	0	0	1	0	1	0	2	2
127.	Bhesa paniculata	BHPA	0	2	2	0	0	0	4	2
128.	Buchanania sessilifolia	BUSE	2	0	0	0	0	0	2	2
129.	Calophyllum curtisii	CALC	0	0	0	0	1	2	3	2
130.	Dacryodes laxa var typica	DALA	0	1	0	0	0	1	2	2
131.	Dacryodes rostrata	DARO	1	0	0	0	0	1	2	2
132.	Dialium laurinum	DILA	0	0	0	0	0	2	2	2
133.	Dillenia grandifolia	DLEX	0	1	0	1	0	0	2	2
134.	Diospyros buxifolia	DOBU	0	1	1	0	0	0	2	2
135.	Elaeocarpus acronodia	ELAM	0	0	0	0	1	1	2	2
136.	Elateriospermum tapos	ELTA	0	0	1	0	0	1	2	2
137.	Eugenia filiformis	EUFI	0	2	1	0	0	0	3	2
138.	Eugenia linocieroidea	EULI	0	0	5	0	0	0	5	2
139.	Eugenia ngadimaniana	EUNG	0	1	1	0	0	0	2	2
140.	Eugenia subdecussata	EUSU	0	0	4	0	0	0	4	2
141.	Eugenia sp. A	EUZA	0	0	2	0	0	0	2	2
142.	Eugenia sp. B	EUZB	0	0	2	0	0	0	2	2
143.	Euodia glabra	EVOD	0	1	1	2	1	0	5	2
144.	Garcinia hombroniana	GARH	0	1	1	0	0	0	2	2
145.	Garcinia nigrolineata	GARN	0	1	1	0	0	0	2	2
146.	Gymnacranthera eugeniifolia	GYEU	0	1	0	1	0	0	2	2
147.	Heritiera elata	HEEL	0	1	0	1	0	0	2	2
148.	Lithocarpus conocarpus	LICO	0	0	1	1	0	0	2	2
149.	Litsea machilifolia	LITS	0	0	2	0	0	0	2	2
150.	Myristica cinnamomea	MYCI	0	1	0	1	0	0	2	2
151.	Nauclea officinalis	NAJU	0	0	2	0	0	0	2	2
152.	Nephelium lappaceum	NELA	0	0	1	0	0	1	2	2
153.	Palaquium microphyllum	PALM	0	0	0	0	1	1	2	2
154.	Palaquium obovatum	PALO	0	1	1	0	0	0	2	2
155.	Pentace triptera	PETR	0	0	2	0	0	1	3	2
156.	Pternandra coerulescens	PTCO	0	0	1	1	0	0	2	2
157.	Ptychopyxis caput-medusae	PTYC	1	0	1	0	2	1	4	2
158.	Santiria tomentosa	SANT	1	0	1	1	0	0	3	2
159.	Shorea gratissima	SHGR	0	0	0	1	0	2	3	2
160.	Xylopia malayana	XYMA	0	2	0	0	0	0	2	2

(Appendix 2 contd.)

	Species	Code	G1	G2	G3	G4	G5	G6	TOT	DI
161.	Antidesma coriaceum	ANOM	0	0	2	1	0	0	3	3
162.	Beilschmiedia maingayi	BEMA	0	0	3	0	0	0	3	3
163.	Calophyllum pulcherrimum	CALP	0	1	0	2	0	1	4	3
164.	Campnosperma auriculatum	CAMA	0	1	6	3	2	4	16	3
165.	Cratoxylon formosum	CRFO	0	0	1	1	0	1	3	3
166.	Dialium kingii	DIKI	0	1	2	0	1	0	4	3
167.	Dipterocarpus kerii	DPRI	0	0	2	1	0	2	5	3
168.	Ganua kingiana	GANK	0	1	2	1	0	0	4	3
169.	Gironniera nervosa	GINE	0	3	1	0	0	0	4	3
170.	Grewia blattaefolia	GRBL	0	1	4	0	0	0	4	3
171.	Lithocarpus encleisacarpus	LIEN	0	0	1	1	1	0	3	3
172.	Litsea elliptica	LITE	0	0	2	1	0	0	3	3
173.	Rhodamnia cinerea	RHTR	1	6	8	1	0	0	16	3
174.	Shorea macroptera	SHMA	0	0	0	2	1	1	4	3
175.	Adinandra dumosa	ADIU	0	27	52	9	2	0	90	4
176.	Artocarpus scortechinii	ARSC	0	0	1	2	1	1	5	4
177.	Blumeodendron tokbrai	BLTO	0	1	2	1	1	0	5	4
178.	Calophyllum ferrugineum	CALF	0	0	2	1	1	0	4	4
179.	Endospermum diadenum	ENDO	0	1	2	1	0	0	4	4
180.	Hopea mengarawan	HOME	0	1	0	3	0	0	4	4
181.	Ixonanthes icosandra	IXIC	0	2	2	0	0	0	4	4
182.	Palaquium gutta	PAGU	0	2	10	13	7	6	38	4
183.	Parishia paucijuga	PARP	0	0	2	0	1	1	4	4
184.	Santiria rubiginosa	SANR	0	0	3	0	0	2	5	4
185.	Scorodocarpus borneensis	SCBO	0	0	3	1	1	0	5	4
186.	Xanthophyllum stipitatum	XAST	0	0	3	1	0	0	4	4
187.	Baccaurea kunstleri	BAKU	0	1	3	0	1	4	9	5
188.	Baccaurea sumatrana	BASU	0	2	2	2	0	0	6	5
189.	Eugenia rugosa	EURA	0	2	1	0	1	1	5	5
190.	Gironniera parvifolia	GIPA	1	3	3	1	0	0	8	5
191.	Gynotroches axillaris	GYNO	0	2	2	2	0	0	6	5
192.	Litsea castanea	LITA	0	0	4	4	0	0	8	5
193.	Ochanostachys amentacea	OCAM	0	2	0	2	0	1	5	5
194.	Pternandra echinata	PTEC	0	1	1	4	0	1	7	5
195.	Shorea leprosula	SHLE	0	2	0	1	3	4	10	5
196.	Artocarpus rigidus	ARRI	0	1	2	3	1	2	9	6
197.	Cyathocalyx ramuliflorus	CYRA	0	1	6	0	0	0	7	6
198.	Ixonanthes reticulata	IXRE	0	0	4	2	4	10	20	6
199.	Koompassia malaccensis	KOMA	0	3	1	1	0	5	10	6
200.	Palaquium semaram	PALS	0	0	1	1	3	1	6	6
201.	Randia scortechinii	RASC	0	7	4	2	0	0	13	6
202.	Shorea pauciflora	SHPA	0	0	3	0	1	5	9	6
203.	Pimelodendron griffithianum	PIGR	0	1	5	2	0	1	9	7
204.	Streblus elongatus	SLOE	1	3	5	6	2	2	19	7
205.	Timonius wallichianus	TIWA	1	6	5	1	0	0	13	7
206.	Santiria griffithii	SANG	1	4	0	3	2	2	12	8
207.	Santiria laevigata	SANL	0	0	2	5	0	1	8	8
208.	Pellacalyx saccardianus	PESA	0	6	9	6	5	2	28	10
209.	Artocarpus lanceifolius	ARLA	0	3	4	4	2	1	15	11
210.	Dipterocarpus caudatus ssp. penangianus	DPRP	0	8	7	5	2	15	37	12
211.	Shorea curtisii	SHCU	0	5	10	5	7	19	46	12
212.	Unknown	ZNKN	1	6	8	1	0	4	20	13
213.	Gluta wallichii	MELW	0	5	15	10	2	2	34	15

Appendix 3. Species with individuals in specified ranges of girth classes.

"TOT" is the Species' Sample Total.
For DI and G see Sect. III (c) & III (d)

a Species with individuals in the whole range of girth classes.

	Species	Code	G1	G2	G3	G4	G5	G6	TOT	DI
1.	Streblus elongatus	SLOE	1	3	5	6	2	2	19	7

b Species which must have individuals from G2 thr'u to G6.

	Species	Code	G1	G2	G3	G4	G5	G6	TOT	DI
1.	Artocarpus lanceifolius	ARLA	0	3	4	4	2	1	14	11
2.	Artocarpus rigidus	ARRI	0	1	2	3	1	2	9	6
3.	Campnosperma auriculatum	CAMA	0	1	6	3	2	4	16	3
4.	Dipterocarpus caudatus ssp. penangianus	DRRP	0	8	7	5	2	15	37	12
5.	Gluta wallichii	MELW	0	5	15	10	2	2	34	15
6.	Palaquium gutta	PAGU	0	2	10	13	7	6	38	4
7.	Pellacalyx saccardianus	PESA	0	6	9	6	5	2	28	10
8.	Shorea curtisii	SHCU	0	5	10	5	7	19	46	12
9.	Streblus elongatus	SLOE	1	3	5	6	2	2	19	7

c Species which must have individuals from G3 thr'u to G6.

	Species	Code	G1	G2	G3	G4	G5	G6	TOT	DI
1.	Atrocarpus lanceifolius	ARLA	0	3	4	4	2	1	14	11
2.	Artocarpus rigidus	ARRI	0	1	2	3	1	2	9	6
3.	Artocarpus scortechinii	ARSC	0	0	1	2	1	1	5	4
4.	Campnosperma auriculatum	CAMA	0	1	6	3	2	4	16	3
5.	Dipterocarpus caudatus ssp. penangianus	DPRP	0	8	7	5	2	15	37	12
6.	Ixonanthes reticulata	IXRE	0	0	4	2	4	10	20	6
7.	Gluta wallichii	MELW	0	5	15	10	2	2	34	15
8.	Palaquium gutta	PAGU	0	2	10	13	7	6	38	4
9.	Palaquium semaram	PALS	0	0	1	1	3	1	6	6
10.	Pellacalyx saccardianus	PESA	0	6	9	6	5	2	28	10
11.	Shorea curtisii	SHCU	0	5	10	5	7	19	46	12
12.	Streblus elongatus	SLOE	1	3	5	6	2	2	19	7

d Species which must have individuals from G4 thr'u to G6.

	Species	Code	G1	G2	G3	G4	G5	G6	TOT	DI
1.	Artocarpus lanceifolius	ARLA	0	3	4	4	2	1	14	11
2.	Artocarpus rigidus	ARRI	0	1	2	3	1	2	9	6
3.	Artocarpus scortechinii	ARSC	0	0	1	2	1	1	5	4
4.	Campnosperma auriculatum	CAMA	0	1	6	3	2	4	16	3
5.	Dipterocarpus caudatus ssp. penangianus	DPRP	0	8	7	5	2	15	37	12
6.	Ixonanthes reticulata	IXRE	0	0	4	2	4	10	20	6
7.	Gluta wallichii	MELW	0	5	15	10	2	2	34	15
8.	Palaquium gutta	PAGU	0	2	10	13	7	6	38	4
9.	Palaquium hexandrum	PAHE	0	0	0	2	1	1	4	1
10.	Palaquium semaram	PALS	0	0	1	1	3	1	6	6
11.	Pellacalyx saccardianus	PESA	0	6	9	6	5	2	28	10
12.	Santiria griffithii	SANG	1	4	0	3	2	2	12	8
13.	Shorea curtisii	SHCU	0	5	10	5	7	19	46	12
14.	Shorea leprosula	SHLE	0	2	0	1	3	4	10	5
15.	Shorea macroptera	SHMA	0	0	0	2	1	1	4	3
16.	Streblus elongatus	SLOE	1	3	5	6	2	2	19	7

Appendix 4. Number of species which have individuals in girth class G1 and/or girth class G2.

"TOT" is the Species' Sample Total.
For G and D1 see Sect. III (c) & III (d) for explanation.

	Species	G1	G2	G3	G4	G5	G6	TOT	DI
1.	Actinodaphne malaccensis	0	1	0	0	0	0	1	1
2.	Adinandra dumosa	0	27	52	9	2	0	90	4
3.	Alstonia angustifolia	0	1	0	0	0	0	1	1
4.	Aporusa bracteosa	1	2	2	0	0	0	5	1
5.	Aporusa sp. A	1	0	0	0	0	0	1	1
6.	Ardisia tuberculata	0	1	1	0	0	0	2	1
7.	Aromadendron elegans	1	0	0	0	0	1	2	2
8.	Artocarpus lanceifolius	0	3	4	4	2	1	14	11
9.	Artocarpus rigidus	0	1	2	3	1	2	9	6
10.	Baccaurea bracteata	1	0	1	0	0	0	2	2
11.	Baccaurea kunstleri	0	1	3	0	1	4	9	5
12.	Baccaurea sumatrana	0	2	2	2	0	0	6	5
13.	Baccaurea sp. B	1	0	0	0	0	0	1	1
14.	Bhesa paniculata	0	2	2	0	0	0	4	2
15.	Blumeodendron tokbrai	0	1	2	1	1	0	5	4
16.	Buchanania sessilifolia	2	0	0	0	0	0	2	2
17.	Calohyllum pulcherrimum	0	1	0	2	0	1	4	3
18.	Calophyllum rubiginosum	0	2	0	0	0	0	2	1
19.	Campnosperma auriculatum	0	1	6	3	2	4	16	3
20.	Canarium sp	0	1	0	0	0	0	1	1
21.	Chisocheton erythrocarpus	0	1	0	0	0	0	1	1
22.	Cryptocarya rugulosa	0	1	0	0	0	0	1	1
23.	Cyathocalyx ramuliflorus	0	1	6	0	0	0	7	6
24.	Dacryodes laxa var typica	0	1	0	0	0	1	2	2
25.	Dacryodes rostrata	1	0	0	0	0	1	2	2
26.	Dacryodes rugosa	0	1	0	0	0	0	1	1
27.	Dialium kingii	0	1	2	0	1	0	4	3
28.	Dialium platysepalum	0	1	1	0	0	1	3	1
29.	Dillenia grandifolia	0	1	0	1	0	0	2	2
30.	Diospyros buxifolia	0	1	1	0	0	0	2	2
31.	Dipterocarpus caudatus ssp. penangianus	0	8	7	5	2	15	37	12
32.	Durio griffithii	0	1	0	0	0	0	1	1
33.	Dyera costulata	0	1	0	0	0	0	1	1
34.	Dysoxylon sp.	0	4	1	0	0	0	5	1
35.	Elaeocarpus polystachyus	1	0	0	0	0	0	1	1
36.	Endospermum diadenum	0	1	2	1	0	0	4	4
37.	Eugenia chlorantha	0	1	0	0	0	0	1	1
38.	Eugenia filiformis	0	2	1	0	0	0	3	2
39.	Eugenia glauca	0	1	0	0	0	0	1	1
40.	Eugenia ngadimaniana	0	1	1	0	0	0	2	2
41.	Eugenia palembanica	0	2	0	0	0	0	2	1
42.	Eugenia rugosa	0	2	1	0	1	1	5	5
43.	Euodia glabra	0	1	1	2	1	0	5	2
44.	Ganua kingiana	0	1	2	1	0	0	4	3
45.	Garcinia hombroniana	0	1	1	0	0	0	2	2
46.	Garcinia nigrolineata	0	1	1	0	0	0	2	2
47.	Gironniera nervosa	0	3	1	0	0	0	4	3
48.	Gironniera parvifolia	1	3	3	1	0	0	8	5

(Appendix 4 contd.)

	Species	Code	G1	G2	G3	G4	G5	G6	TOT	DI
49.	Grewia blattaefolia		0	1	4	0	0	0	5	3
50.	Gymnacranthera eugeniifolia		0	1	0	1	0	0	2	2
51.	Gynotroches axillaris		0	2	2	2	0	0	6	5
52.	Heritiera elata		0	1	0	1	0	0	2	2
53.	Hopea mengarawan		0	1	0	3	0	0	4	4
54.	Horsfieldia brachiata		0	1	0	0	0	0	1	1
55.	Ixonanthes icosandra		0	2	2	0	0	0	4	4
56.	Knema intermedia		0	1	0	0	0	0	1	1
57.	Koilodepas longifolium		0	1	0	0	0	0	1	1
58.	Koompassia malaccensis		0	3	1	1	0	5	10	6
59.	Macaranga lowii		0	1	0	0	0	0	1	1
60.	Mallotus penangensis		1	3	0	0	1	0	5	1
61.	Maesa ramentacea		0	1	0	0	0	0	1	1
62.	Gluta wallichii		0	5	15	10	2	2	34	15
63.	Meliosma pinnata		0	1	1	0	0	0	2	2
64.	Myristica cinnamomea		0	1	0	1	0	0	2	2
65.	Euphoria malaiense		1	0	0	0	0	0	1	1
66.	Nothaphoebe umbelliflora		0	1	0	0	0	0	1	1
67.	Ochanostachys amentacea		0	2	0	2	0	1	5	5
68.	Palaquium gutta		0	2	10	13	7	6	38	4
69.	Palaquium obovatum		0	1	1	0	0	0	2	2
70.	Pellacalyx saccardianus		0	6	9	6	5	2	28	10
71.	Pimelodendron griffithianum		0	1	5	2	0	1	9	7
72.	Polyalthia sp.		0	2	0	0	0	0	2	1
73.	Pternandra echinata		0	1	1	4	0	1	7	5
74.	Ptychopyxis caput-medusae		1	0	1	0	2	1	5	2
75.	Randia densiflora		1	3	2	0	0	0	6	1
76.	Randia scortechinii		0	7	4	2	0	0	13	6
77.	Rhodamnia cinerea		1	6	8	1	0	0	16	3
78.	Santiria apiculata		1	1	0	0	0	0	2	1
79.	Santiria griffithii		1	4	0	3	2	2	12	8
80.	Santiria tomentosa		1	0	0	1	0	0	2	1
81.	Shorea curtisii		0	5	10	5	7	19	46	12
82.	Shorea leprosula		0	2	0	1	3	4	10	5
83.	Streblus elongatus		1	3	5	6	2	2	19	7
84.	Timonius wallichianus		1	6	5	1	0	0	13	7
85.	Teijsmanniodendron coriaceum		0	2	0	0	0	0	2	1
86.	Urophyllum glabrum		0	1	0	0	0	0	1	1
87.	Vatica sp. A		0	1	0	0	0	0	1	1
88.	Xylopia malayana		0	2	0	0	0	0	2	2
89.	Unknown		1	6	8	1	0	4	20	13

The list above contains 87 known species and the "unknown" group with 20 trees. The individuals are distributed in the various girth classes as shown below:

G1	G2	G3	G4	G5	G6	TOT
21	181	202	102	45	82	633